GENERAL PORFIRIO DÍAZ,
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DEDICATION.

In acknowledgment of the cordial hospitality extended to the visiting members of the Institute, at the Mexican meeting, this volume is dedicated to the President and the people of the United States of Mexico.

PREFACE.

As explained on the title-page, this volume contains the papers of 1901 which deal, more or less directly, with the mineral resources and industries of Mexico. It also contains the Proceedings of the Mexican meeting and an illustrated account of the Excursions and Entertainments connected therewith.

The other papers presented at the Mexican meeting will be found in Volume XXXI.

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*BENTLEY, GEORGE ROLLAND, Genl. Supt. Central Iron and Steel Co.,
Harrisburg, Pa. '96
*BENTLEY, ROBERT, Pres., The Carbon Limestone Co., Secy., Ohio
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*BERG, P. T., Mech. Engr................Homestead Steel Works, Munhall, Pa. '90
*BERKEN, JOHN..Boulder, Jefferson Co., Mont. '00
*BERMINGHAM, JNO , JR., Supt. ....Cal. Powder Works, Pinole, Cal. '02
*BERRAY, NILES S., Supt........ ....The United Globe Mines, Globe, Ariz. '99
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*BILHARZ, OSCAR M., Min Engr., Supt., Doe Run Lead Co., etc., Flat River, Mo. '92
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*BLUETT, A. NEWTON, ...Oaklia, Chaucer Road, Bedford, England. '96
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**Britten, Thomas J., Wolhuter Gold Mining Co., Johannesburg, Transvaal, So. Africa. '95
*Broad, Wallace, Geol. and Min. Engr., Care Hong Kong and Shanghai Bnkg. Corp., Shanghai, China. '01
*Brock, Arthur..Lebanon, Pa. '87
*Brock, Charles, Pres...........Boonton Iron and Steel Co., Boonton, N. J. '81
*Brockunier, Samuel H , Mining Engr.................. ...Wheeling, W. Va. '00
*Broden, Albert, Supt., Blast Furnaces......Reading Iron Co., Reading, Pa. '89
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*Bromly, Alfred H., Min. Engr..........18 Eldon St., London, E. C., England. '97
*Brooke, Robert E., Blast Furnace Mgr...........Birdsboro, Berks Co., Pa. '02
**Brooks, Alfred H., Geologist......U. S. Geol. Survey, Washington, D. C. '00
*Brophy, James, Mine Operator....................................Coopers, W. Va. '01
*Brown, Alexander E....Brown Hoisting Machinery Co., Cleveland, Ohio. '75
**Brown, Amos P., Prof., Geology and Mineralogy, Univ. of Pennsylvania, Philadelphia, Pa. '88
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*Brown, Austin H., Jr., Genl. Mgr. and Cons. Engr., Trinity Copper Co., Kennett, Shasta Co., Cal. '92
*Brown, Cony T., Mgr., Mine Development Association, Socorro, New Mex. '00
*Brown, Donald C....................Apartado 132, San Luis Potosi, Mexico. '01
*Brown, E. C., Genl. Supt., Chest Creeks Land and Improvement Co., Patton, Cambria Co., Pa. '86
*Brown, Edward L., Treas. and Supt., Chicago Drop Forge and Foundry Co., Kensington, Ill. '81
*Brown, E. Percy, Min. Engr..........................Bridgewater, Nova Scotia. '98
*Brown, Elwin F., Genl. Mgr.............Pewabic Co., Iron Mountain, Mich. '91
†Brown, Fayette, Prest. of Manufacturing Cos., Perry-Payne Bldg., Cleveland, Ohio. '75
*Brown, Frederick C., Genl. Mgr., Komata Reefs G. M. Co., Ltd., Komata, via Paeroa, Auckland, New Zealand. '00
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*Brown, Lucius P., Analytical Chemist and Geologist......Nashville, Tenn. '95

*Brown, Raymond, Mgr..............Duquesne Reduction Co., Pittsburg, Pa. '95
*Brown, R. Gilman, Genl. Mgr., Standard Cons. Mining Co.,
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*Brown, Walter S., Min. Engr............1627 Polk St., San Francisco, Cal. '02
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*Brown, William S., Min. Engr., Care W. Queen, 3 Tudor St.,
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*Budrow, W. B............Care Phila. Plant, Am. S. & R. Co., Pueblo, Colo. '00
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*Bulkley, Henry W............................141 Broadway, New York, N. Y. '79
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*Burch, Albert, Mgr., Bunker Hill and Sullivan M. and Concent. Co.,
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*Burrell, Henry, Mine Mgr., Victor Coal Co., 602 Plymouth Bldg., Chicago, Ill. '00
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*Carson, Arthur C., Supt..................Indian Gold Min. Co., Pony, Mont. '84
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*Case, Charles M., Treas., Royal Elevator Co.,
55 Chamber of Commerce, Minneapolis, Minn. '96
*Case, George D.......................Anaconda Copper Co., Anaconda, Mont. '99
*Case, John J., Genl. Mgr...............Lake Superior Co., Houghton, Mich. '94
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*Chamberlain, H. S., Pres.................Roane Iron Co., Chattanooga, Tenn. '75
*Chambers, Robert E., Mgr., Wabana Iron Mine,
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New York, N. Y. '90
*Channing, J. Parke, Cons. Min. Engr.......34 Park Pl., New York, N. Y. '84
*Chanute, O., Cons. Engr...........................413 E. Huron St., Chicago, Ill. '79
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*Chapman, Robert H., Topographer, U. S. Geol. Survey, Washington, D. C. '97
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*Chase, Frank D...Dedham, Mass. '84
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*CHILD, ALFRED T., Met, Eiler's Plant, Amer. Sm. & Ref. Co., Pueblo, Colo. '00
**CHIPPENDALE, ARTHUR, Chemist, American Club, Mexico City, Mexico. '99
*CHISHOLM, JOHN, Metallurgist, Care Donnybrook Gold Fields, Ltd., Donnybrook, Western Australia. '00
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**CHOATE, WAYNE, Min. Eng.........800 Union Trust Bldg., Detroit, Mich. '02
*CHOUTEAU, PIERRE, Pres., Iron Mountain Co., Security Bldg., St. Louis, Mo. '76
**CHRISTIAN, AUGUST, Chief Engr., Min. Dept., Anaconda Copper M. Co., Butte, Mont. '99
*CHRISTIANSEN, HERMAN B., Chemist......Republic M. & M. Co., Rome, Ga. '95
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*CHRISTY, SAMUEL B., Prof., Min. and Met., University of California, Berkeley, Cal. '83
*CHURCH, ALBERT K.........................National Tube Co., Pittsburg, Pa. '92
*CHURCH, E. D., JR., Secy., Church & Dwight Co., 63 Wall St., New York, N. Y. '88
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*CLARK, ALLAN J., Chief Assayer.........Homestake M. Co., Lead, So. Dak. '97
*CLARK, CLARENCE M., Banker, E. W. Clark & Co., Bullitt Bldg., Philadelphia, Pa. '88
*CLARK, EDWIN M., Supt. of Smelter, 1982 Bonsallo Ave., Los Angeles, Cal. '91
†CLARK, FREDERICK................................Mills Bldg., San Francisco, Cal. '98
*CLARK, GEORGE C., Min. Engr..Bisbee, Ariz. '01
*CLARK, GEORGE M., Min. Supt., River Hill M. and M. Co., Placerville, Cal. '99
*CLARK, JAMES M., Civ. and Min. Engr..............Kanawha Falls, W. Va. '02
*CLARK, JOSEPH K., Supt. of Mines............ ....Portland, Oregon. '87
*CLARK, JOSIAH H., Min. Engr..................18 Wall St., New York, N. Y. '98
*CLARK, LINDESAY C., Min. Engr., Prells Bldg., Collins St., Melbourne, Victoria, Australia. '99
**CLARK, MAURICE, Assayer.....................Apartado 233, Oaxaca, Mexico. '86
*CLARK, V. V., Min. Engr............................Albuquerque, New Mexico. '99
*CLARK, WALTON, Gas Engr., Gen. Supt. The United Gas Imp. Co., Broad and Arch Sts., Philadelphia, Pa. '96
*CLARK, WILLIAM A., Pres. United Verde Copper Co., etc., 49 Wall St., New York, N. Y. '82
*CLARKE, CHARLES A., Min. Engr., Morning Star Syndicate, Ltd., Loope, Alpin Co., Cal. '00

*Clarke, E. A. S., Genl. Mgr., Deering Harvester Co., 16 Fullerton Ave., Chicago, Ill. '85
*Clarke, Hopewell..........................775 Portland Ave., St. Paul, Minn. '96
*Clarke, Roy H., Min. Engr., Mgr., I. X. L. Gold M. Co., Rossland, B. C., 19 Ziegler Block, Spokane, Wash. '01
*Clarke, Wm. B., Elect. Engr..........Genl. Elec. Co., Schenectady, N. Y. '02
*Claudet, Arthur C., Chem. and Met. Engr., 6 Coleman St., London, England. '86
*Cleaveland, Newton.........Boston & Oroville Mining Co., Oroville, Cal. '01
†Cleland, E. Davenport, Min. Mgr., Bayley's G. M., Ltd., Coolgardie, Western Australia. '90
*Clement, F. H., Engr. and Contractor....32 S. Broad St , Philadelphia, Pa. '92
*Clement, Harrison Edward, Min. Engr.........Bingham Canyon, Utah. '02
**Clement, Victor M., Cons. Min. Engr., McCormick Bldg., Salt Lake City, Utah. '87
*Clements, J. Morgan, Geol., Asst. Prof. Univ. of Wis., Asst. Geol. U. S. Geol. Survey, 609 Lake St., Madison, Wis. '01
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*Clerc, F. L..Hotel Metropole, Denver, Colo. '87
*Cleveland, Newton..Palo Alto, Cal. '01
**Cliff, Capt. John, Broker..........................Ontario Hotel, Chicago, Ill. '80
*Clouston, T. Harold, Mine Mgr., Ringarooma Tin Mines, Ltd., Derby, Tasmania, '01
*Clunes, Gordon, Asst. in Min. Dept., The Exploration Co., Ltd., 11 Cornhill, London, E. C., England. '99
*Clymer, Edward T., Furnace Mgr., Allentown Iron Works, 924 N. Front St., Allentown, Pa. '82
*Clymer, Frederick H., Min. Engr.............249 N. Fifth St., Reading, Pa. '97
*Cobbe, Hervic N. G............P. O. Box 251, Kalgoorlie, Western Australia. '01
*Cockerell, Leslie M., Genl. Mgr., United Mexican Min. Assn., Ltd., Guanajuato, Mexico. '00
*Codington, Edmund W., Pres.........Am. Min. and Imp. Co., Bartow, Fla. '90
*Coe, William W., Civ. Engr....Norfolk & Western Ry. Co., Radford, Va. '83
*Coffin, Charles E., Charcoal Pig Iron Mfr.....................Muirkirk, Md. '82
*Coffin, William C., V. Pres., Riter Conley Mfg. Co., 55 Water St., Pittsburg, Pa. '92
*Coghlan, Francisco M., Min. Engr..................Catorce, S. L. P., Mexico. '91
**Cogswell, William B., V. Pres. & Managing Director, Solvay Process Co., Syracuse, N. Y. '72
**Cohen, E. H. A............Rand Club, Johannesburg, Transvaal, So Africa. '94
*Cohen, H. A., Min. Engr.........Room 324, 30 Broad St., New York, N. Y. '89
*Cohen, Louis, Met................................1239 Welton St., Denver, Colo. '01
*Colbath, Harry, Mill Supt.....Con. Mercur G. Mines Co., Mercur, Utah. '00
*Colbath, L. U., Mine Mgr. and Owner...P. O. Box 717, Salt Lake City, Utah. '87
*Colby, Albert Ladd, Met. Engr., Bethlehem Steel Co., So. Bethlehem, Pa. '83
*Colby, Safford K., Civ. Engr., Pittsburg Red. Co., 99 John St., New York, N. Y. '00
*Cole, Arthur A., Assayer and Chemist, War Eagle and Center Star Mines, Rossland, B. C., Canada. '02
*Cole, T. F., Pres. and Genl. Mgr. of Iron Mines................Duluth, Minn '90
*Coleman, Bertrand Dawson..Lebanon, Pa. '95
*Colley, Bernard T.......................Amer. Sm. & Ref. Co., Omaha, Neb. '88

*Collier, John H., Min. Engr.......................Haydenhill, Lassen Co., Cal. '00
**Collin, Emile C., Mgr., Cie. des Mines et Usines d'Escombrera, Bleyberg (Spain and Belgium), 49 Rue de Miromesnil, Paris, France. '86
*Collings, Burton I., Care Harvey & Co., P. O. Box 953, Johannesburg, Transvaal, So. Africa. '02
*Collingwood, Francis, Cons. Engr., and Expert Civil Service Examiner, 346 Broadway, New York, N. Y. '82
*Collins, George E., Min. Eng............ ..217 Boston Bldg, Denver, Colo. '00
**Collins, Henry F., Min. and Met. Engr., J. H. Collins & Son, 702 Salisbury House, Finsbury Circus, London, E. C., England. '96
*Collins, Horace F....................................Hermanos, Coah., Mexico. '00
*Collins, W. J.................. P. O. Box 308, Melbourne, Victoria, Australia. '93
*Collord, George L., Supt.........Shenango Furnace Co., Sharpsville, Pa. '01
**Colquhoun, James, Genl. Mgr............Arizona Copper Co., Clifton, Ariz. '98
*Colton, Charles A., Director, Newark Technical School, 367 High Street, Newark, N. J. '74
**Colvin, Verplanck.................N. Y. State Land Survey, Albany, N. Y. '81
*Colwell, James M., Secy. and Treas., N. Y. Camera Mfg. Co., 164 W. 27th St., New York, N. Y. '93
*Colyar, Louis S., Pres., Eagle Iron Co., Rome Furnace Co., Chattanooga, Tenn. '85
*Comstock, Charles W., Prof. Min. Eng., Colorado School of Mines. Golden, Colo. '00
*Comstock, Prof. Theodore B., Cons. Engr., 534 Stimson Block, Los Angeles, Cal. '80
*Conant, H. D., Asst. Supt...Lake Superior Smelting Co., Dollar Bay, Mich. '88
*Conley, Owen J., Min. Eng...................96 Broadway, New York, N. Y. '02
*Connell, William, Coal Operator...............Connell Bldg., Scranton, Pa. '87
*Conner, Eli T..Cresson, Pa. '92
*Conner, John T., Mine Supt................" The Monticello," Helena, Mont. '00
*Connor, Charles..................................4840 Lytle St., Hazlewood, Pa. '86
**Connor, S. B....................................2009 Central Ave., Alameda, Cal. '88
*Conradson, Pontus H., Chief Chemist, Galena Signal Oil Works, Franklin, Pa. '92
*Cook, Edgar S., Pres.............Warwick Iron and Steel Co., Pottstown, Pa. '77
*Cook, Edward H., Cons. Engr., Supt., Am. Sm. & Ref. Co., Asientos, Aguascalientes, Mexico. '96
*Cook, Robert A., Genl. Mgr., Standard Silica Cement Co., 66 Maiden Lane, New York, N. Y. '83
*Cooke, Henry M. A., Min. Engr., Oergum G. M. Co., Ltd., Oorgaum, Mysore, India. '01
**Cooke, Lewis H..........Royal School of Mines, London, S. W., England. '01
*Coolidge, Walter G., Copper Ref., Chicago Copper Ref. Co., 310 Western Union Bldg., Chicago, Ill. '82
*Coom, Henry.......................Stratton's Independence Mine, Victor, Colo. '02
†Coombs, Harold L.........Old Dominion Cop. S. and R. Co., Globe, Ariz. '02
*Cooper, Augustus S., Min. Engr.....219 Crocker Bldg., San Francisco, Cal. '00
*Cooper, Edward, Iron Merchant, Cooper, Hewitt & Co., 17 Burling Slip, New York, N. Y. '74
††Cooper, James B., Supt., Calumet and Hecla Sm. Wks., South Lake Linden, Mich. '99
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**CORBOULD, WILLIAM HENRY, Hannan's Reward, Ltd., Kalgoorlie, Western Australia. '92

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**CORBUS, J. PARKER, Mine Mgr...........1511 Jones St., San Francisco, Cal. '96

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*CORNELIUS, WILLIAM A., Asst. Mgr.......Natl. Tube Co., McKeesport, Pa. '01

*CORNELL, RUSSELL T., Min. Engr., Care Copper Queen Cons. Min. Co., Douglas, Ariz. '02

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*CORNING, FREDERICK G., Min. Engr.......15 Broad St, New York, N. Y. '77

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*COSGRO, JNO. P., Mech. Engr., War Eagle Con. Min. and D. Co., Rossland, B. C., Canada. '01

*COSTE, EUGÈNE, Min. Engr............171 Lowther Ave., Toronto, Ont., Can. '87

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*COUNTRYMAN, T. R., Min. Engr., U. S. Dep. Mine Surveyor, Cripple Creek, Colo. '89

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†COX, STERLING B.........................67 Harrison St., East Orange, N. J. '01

*COX, THOMAS, Mgr., Larsen & Greenough, "Morning" and "You Like" Mines, Mullan, Idaho. '01

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*COXE, CHARLES E., Ore Buyer, Cia. Comercial Beneficiadora de Minerales, Zacualpan, E. de Mexico, Mexico. '00

**COXE, ECKLEY B., JR.................Anthracite Coal Operator, Drifton, Pa. '93

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*Crawford, Henry E., Min. Engr......220 W. 28th St., New York, N. Y. '02
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*Crawford, John L., Chemist...............26 S. Jefferson St., Newcastle, Pa. '84
*Cremer, Felix, Engr., Care La Gran Fundicion Central Mexicana,
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**Crocker, A. L., Mech. Engr.....2515 Blaisdel Avenue, Minneapolis, Minn. '80
*Crocker, George A., Iron Merchant..........99 John St., New York, N. Y. '79
*Croft, Henry, Cons. Engr...............................Victoria, B. C., Canada. '00
*Crooke, Robert L.............................100 E. 17th St., New York, N. Y. '89
*Crooker, Ralph, Jr., Mech. Engr..................................Acton, Mass. '81
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*Cross, Arthur D.......................331 Montgomery St., San Francisco, Cal. '91
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*Crowell, Benedict, Min. Engr., Crowell & Peck,
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*Croxton, Samuel W., Pres. and Genl. Mgr., The Penn Iron & Coal Co.,
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**Cuevas, Luis G., Assayer..........Apartado 148, San Luis Potosí, Mexico. '97
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Palmer, So. Australia. '97
*Cullum, James B., Genl. Sales Agent, Harbison-Walker Co.,
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*Cummings, George P., Civ. and Min. Engr..................Marquette, Mich. '81
*Cummings, William N., Min. Engr. & Met., Genl. Supt. for The Dwight-
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*Cummins, Leon, Cyanide Chemist and Elec. Engr.,
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*Cunningham, Eckley S., Mine Supt..................................Drifton, Pa. '99
*Cunningham, James S., Supt., Berwind-White Coal Min. Co., Windber, Pa. '83
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**Currie, Walter, Min. Engr.................Bulawayo, Rhodesia, So. Africa. '96
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*Dan, Takuma, Care Mitsui M. Co., No. 4, Suruga Cho Nihonbashi-Ku,
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*Dane, Edward G....14 Burnfoot Ave., Fulham, S. W., London, England. '02
*Danforth, A. H..Florence, Colo. '82
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*DARLINGTON, WAYNE, Min. Engr. and Met.................Antelope, Idaho. '95
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London, W., England. '91
*DAVEY, THOMAS N., Mine Owner.................Davey & Son, Carthage, Mo. '97
*DAVID, W. M., Nassau Copper Wks.,
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*DAVIDOV, ISIDOR, Min. Engr., Santa Barbara Gold Placer Co ,
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*DAVIDSON, GEORGE M., Chemist, Chicago & N. W. Ry. Co......Chicago, Ill. '81
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*DAVIDSON, WILLIAM S.,. Min. Engr., Care Clarkson & Co.,
Port Arthur, China. '96
*DAVIES, EDWARD H., Min. Engr., 6 Great Winchester St.,
London, E. C., England. '00
*DAVIES, HYWEL, V. Pres...............Central Coal & Iron Co., Kensee, Ky. '99
*DAVIES, WILLIAM H., State Mine Inspector, P. O. Box 743, Hazleton, Pa. '97
*DAVIS, BRITTON Mine Owner and Mgr..............Box 127, El Paso, Texas. '90
*DAVIS, CARL R., Min. Engr., Supt , Centre Star M. Co., Ltd., and
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*DAVIS, CHARLES H., Cons. Engr................25 Broad St., New York, N. Y. '00
*DAVIS, CHARLES S..Reynoldsville, Pa. '01
*DAVIS, CHARLES W., Asst. Sales Mgr., Standard Underground Cable Co.,
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*DAVIS, F. HARLEY, V. Pres. and Genl Mgr., Davis Calyx Drill Co.,
128 Broadway, New York, N. Y. '99
*DAVIS, PROF. FLOYD, Analytical and Consulting Chem. and Min. Engr.,
Iowa Loan & Trust Bldg., Des Moines, Iowa. '83
*DAVIS, FRANK S., Min. Engr., Diamond C. & C. Co.,
Diamondville, Uinta Co., Wyoming, '01
*DAVIS, GEORGE C., Anal. and Cons. Chemist, 39 S. 10th St., Philadelphia, Pa. '93
*DAVIS, HERMAN, Owner and Mgr., Nevada Reduction Works,
Dayton, Lyon Co., Nev. '01
*DAVIS, JAMES C., Genl. Supt., Care Leighton & Howard Steel Co.,
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*DAVIS, LEWIS K., Mech. Engr....................................Indianapolis, Ind. '93
*DAVIS, LOUIS M...........................320 Sansome St., San Francisco, Cal. '84
*DAVIS, MORGAN, JR., Min. Engr.,
Rooms 42 and 43 Coal Exchange, Scranton, Pa. '93
*DAVIS, STEWART A., Div. Supt.......Am. Sheet Steel Co., Vandergrift, Pa. '01
*DAVIS, WILLIAM C., Mgr., F. M. Davis Iron Works Co.,
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*DAWSON, T. LAUNCELOT, Min. Engr., Yangtse Valley Co., Ltd., 49 Szechuen Road, Shanghai, China. '96
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*Firmstone, Harry, Pres., Longdale I. Co., 608 Chestnut St., Philadelphia, Pa. '75
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*Fisher, Clark, Civ. and Min. Engr......Eagle Anvil Wks., Trenton, N. J. '71
*Fisher, Thomas, Genl. Supt., Berwind-White Coal M. Co., 305 Betz Bldg., Philadelphia, Pa. '89
*Fisher, William B., Min. Engr., Genl. Mgr., Am. Zinc, Lead & Sm. Co., Carterville, Mo. '92
*Fisk, James H., Mine Engr. and Analytical Chem., 204½ Washington St., Portland, Oregon. '00
**Fitch, Max B., Supt., Graphic Sm. Wks., Magdalena, Socorro Co., New Mexico. '98
†Fitzgerald, J. Morton, Secy., Crane Iron Wks., Empire Steel & Iron Co., etc., Catasauqua, Pa. '01
*Fitzsimmons, Francis J., Engr...................Banamichi, Sonora, Mexico. '98
*Flack, Charles L., Chemist...........Care Atha Steel Co., Harrison, N. J. '90
*Flagg, Stanley G., Jr., Stanley G. Flagg & Co., 424 N. 19th St., Philadelphia, Pa. '92
*Flaherty, Robert H., Min. Engr............Port Arthur, Ontario, Canada. '93
*Fleming, Edward P., Min. Engr.......................................Troy, Ariz. '02
*Fleming, John B., Supt., Silver King Mill......................Park City, Utah. '97
*Fletcher, Charles R., Chemist...........82 Equitable Bldg., Boston, Mass. '85
*Fluker, Wm. H., Min. Engr., Columbia M. Co...................Tatham, Ga. '02
**Flynn, Francis N., Acting Mgr., Avino Mines of Mexico, Ltd., San Gabriel, Durango, Mexico. '98
*Fogh, H. P..Seattle, Wash. '99
**Fohr, Franz, Min. Engr. & Met...........132 Nassau St., New York, N. Y. '75
*Foote, Arthur De W., Supt......North Star Mines Co., Grass Valley, Cal. '00
*Foote, Charles H..................................Lock Box 1123, Phœnix, Ariz. '88
*Foote, Emerson L.............................5833 Bartmer Ave., St. Louis, Mo. '82
*Foote, Frederick H............................1037 The Rookery, Chicago, Ill. '90
**Forbes, Donald G.........Great Western Mines, Ferguson, B. C., Canada. '94
*Forbes-Leith, A. J., Pres...Joliet Steel Co., 71 Broadway, New York, N. Y. '79
*Forbes, Paul R., Metallurgist........Walsh Hall & Co., Yokohama, Japan. '95
*Ford, Edward L., Genl. Supt.....Youngstown Steel Co., Youngstown, Ohio. '79
*Fordyce, John R., V. Pres. and Genl. Mgr., Thomas Fordyce Mfg. Co., 2223 Louisiana St., Little Rock, Ark. '92
**Forrester, Robert, Geol. and Min. Engr., P. O. Box 1254, Salt Lake City, Utah. '02
*Forsyth, Alexander, Min. Engr. and Met., P. O. Box 557, Cripple Creek, Colo. '97
*Forsyth, Robert, Cons. Engr.........................1143 Rookery, Chicago, Ill. '75
*Forsythe, Robert J................................2614 W. 3d St., Chester, Pa. '96
*Foster, Alfred L., Civ. Engr., 222 Victoria Arcade, Auckland, New Zealand. '00
*Foster, Clement Le Neve, Prof. of Mining, Royal College of Science, South Kensington, London, S. W., England. '93

*FOSTER, ERNEST LE NEVE, Min. Engr., 419 Taber Opera House,
Denver, Colo. '75
*FOSTER, FLOYD J. ....Villaldama, N. L., Mexico. '02
†FOSTER, OSCAR R., Inspector.............Carnegie Steel Co., Homestead, Pa. '99
*FOSTER, PHILIP L., Genl. Mgr.........El Oro M. & Ry. Co., El Oro, Mexico. '95
*FOSTER, RUFUS J., V. Pres. and Mgr. of Periodical Dept., Internat.
T. B. Co., Scranton, Pa. '90
*FOUCAR, EDOUARD L., Min. Engr.........Sterns, Roger & Co., Denver, Colo. '85
*FOWLER, EDWARD J., Met..................719 Cole Street, San Francisco, Cal. '00
*FOWLER, SAMUEL S., Mgr & Min. Engr., London & B. C. Goldfields, Ltd.,
Nelson, B. C., Canada. '92
*FRANCIS, GEORGE G., Min. Engr., 9 Queen St. Place, Upper Thames St.,
London, England. '80
*FRANCIS, LEWIS W., Secy., Witherbee, Sherman & Co., Inc.,
71 Broadway, New York, N. Y. '89
**FRANCKLYN, CHARLES G.......................29 Broadway, New York, N. Y. '80
*FRANKE, EMIL A., Min. Engr. and Supt., The New Departure Mining
and Milling Co., Cordes, Ariz. '02
*FRASCH, H., Oil Refiner......................681 Euclid Ave., Cleveland, Ohio. '93
*FRASER, JOSEPH D., Mgr., Iron and Coke Depts., Nova Scotia Steel and Coal
Co., Ltd., New Glasgow, Nova Scotia. '94
**FRAZER, DR. PERSIFOR, Geol. & Chem., 1042 Drexel Bldg., Philadelphia, Pa. '71
*FRAZIER, B. W., Prof. Mineralogy and Metallurgy, Lehigh University,
South Bethlehem, Pa. '71
*FRECHEVILLE, ROBERT J., Min. Engr., 7 Lothbury, London, E. C., England. '84
**FRECHEVILLE, WILLIAM, Min. Engr., 35 Queen Victoria St.,
London, E. C., England. '84
*FREELAND, FRANCIS T., Mgr., Durant M. Co., etc.,
P. O. Box 1016, Aspen, Colo. '85
*FREELAND, WILLIAM H., Genl. Mgr., D. S. Coal & Iron Co., Isabella, Tenn. '01
*FREEMAN, STANTON S., Supt. of Furnaces, Carbon Iron & Steel Co.,
Parryville, Pa. '01
†FREEMAN, WILLIAM COLEMAN, Chairman Robesonia Iron Co., Ltd.,
Robesonia, Berks Co., Pa. '77
*FRENCH, EDMUND L., Met. Engr., Crucible Steel Co. of America,
Syracuse, N. Y. '00
*FRICK, H. C., Coke Mfr..........................Carnegie Bldg., Pittsburg, Pa. '79
*FRICKE, F. G., Analytical and Cons. Chemist.....Bissell Blk., Pittsburg, Pa. '79
*FRICKE, JOHN H., Mining...................................Hillsboro, New Mex. '88
*FRITZ, JOHN.................... ....Bethlehem, Pa. '72
*FROEHLING, HENRY, Analytical Chem., 17 S. Twelfth Street, Richmond, Va. '90
*FROSSARD, JOHN D., Cons. and Min. Engr...Orthez, Basses-Pyrenees, France. '85
*FUCHS, FERNANDO C., Min. Engr., Sociedad de Ingenieros,
Apartado 981, Lima, Peru, So. America. '02
*FUENTE, JESUS DE LA, Member of State Congress and Chief Engr. of the
Nadadores Valley Co., Nadadores, Coahuila, Mexico. '02
*FULLER, JAMES W., Genl. Mgr., McKee, Fuller & Co. Car Wheel and
Axle Wks., Catasauqua, Pa. '94
*FULLER, JAMES W., JR..Catasauqua, Pa. '94
*FULTON, JOHN, Min. Engr........................136 Park Pl., Johnstown, Pa. '72
*FULTON, WALTER M., Genl. Mgr., Taitapu Gold Estates, Collingwood,
Nelson, New Zealand. '97

*FURNESS, DWIGHT, Merchant and Miner, Apartado 2, Guanajuato, Mexico. '02
*FURNESS, JAMES W., Assayer & Chem., Golden Cycle M. Co.,
Goldfield, Colo. '00
*FUSZ, PAUL A..............................422 Security Bldg., St. Louis, Mo. '79

**GAGE, ELIPHALET B., Pres., Congress Gold Co. and Tombstone Con. Mines
Co., Ltd., Tombstone, Ariz. '99
†GAINES, AMBROSE P.. ....Bessemer, Ala. '88
*GALLAGHER, JAMES B., Assayer and Chem., Colo. Sm. & M. Co.,
Butte, Mont. '00
*GARCIA, TELESFORO, JR., Engineering, Sta. Teresa 2, Apartado 463,
Mexico City, Mexico. '02
*GARDNER, G. CLINTON, Flemington Coal and Coke Co,
35 Wall St., New York, N. Y. '78
*GARDNER, GEORGE C., Min. Engr.....................................Address wanted. '83
*GARFIELD, CHARLES D.....................................Box 327, Juneau, Alaska. '02
*GARLICHS, HERMAN, Supt, Lead Dept., Perth Amboy Plant, Am. Sm. &
Ref. Co., Maurer, N. J. '89
*GARRETSON, OLIVER S., Smelter & Mfr.....786 Ellicott Sq., Buffalo, N. Y. '98
*GARRETT, WILLIAM, Pres., Garrett-Cromwell Engineering Co.,
1101 New England Bldg., Cleveland, Ohio. '81
*GARRIGUES, W. E., Chem. Engr............1123 Broadway, New York, N. Y. '98
*GARRISON, F. LYNWOOD, Min. Engr....1019 Clinton Street, Philadelphia, Pa. '83
*GARSIDE, GEORGE W., U. S. Surveyor and Min. Engr., Juneau City, Alaska. '93
*GARTHWAITE, E. H., Resident Min. Engr., British South Africa Co.,
Bulawayo, Rhodesia, So. Africa. '82
*GARVIN, JOHN M., Furnace Mgr. Brass Fdy. & Mach. Co., Rock Run, Ala. '92
*GATZMER, WILLIAM C., Civ. and Mech. Engr.....Tacony, Philadelphia, Pa. '88
*GAUJOT, CLAUDE L., Civ. and Min. Engr., Ohio & Big Sandy Coal Co.,
Williamson, W. Va. '00
*GAY, WARE B., Receiver, Richmond Coal M. & Mfg. Co., Mayo Bridge,
Richmond, Va. '95
*GAYHART, WALTER C., Min. Engr. and Met., Tonopah City M. Co.,
Austin, Nev. '00
*GAYLEY, JAMES....Care U. S. Steel Corp., 71 Broadway, New York, N. Y. '80
*GAYLORD, FRANK B., Blast Furnace Mgr., Deseronto Iron Co., Ltd.,
Deseronto, Ont., Canada. '00
**GAZZAM, JOSEPH P., Genl. Mgr., Simmer & Jack Prop. Mines, Ltd.,
P. O. Box 192, Germiston, Transvaal, So. Africa. '84
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*GEORGE, R. D., Prof. of Geology and Petrology, U. of I., Iowa City, Iowa. '02
*GEPPERT, RICHARD M., Min. Engr.............................Silver Peak, Nev. '02
*GERHAUSER, WILLIAM, Pres., Deseronto Iron Co., Ltd., & The Arizona Co.,
614 Majestic Bldg., Detroit, Mich. '88
*GERMANN, FRANZ.................................La Paz, Bolivia, So. America. '00
*GIBB, ALLAN, Miner and Metallurgist, The Queensland Copper Co., Ltd.,
Mount Perry, Queensland, Australia. '00
*GIBSON, CHARLES H., Min. Engr............P. O. Box 1479, New York, N. Y. '82
*GIBSON, ROBERT, Mine Mgr......................Kalgoorlie, Western Australia. '92
*GIBSON, THOMAS W., Dir...........Bureau of Mines, Toronto, Ont., Canada. '01
*GIFFORD, STANLEY, Treas. & Dir., Montana Ore Purchasing Co., U. S. C.
Co., & Nipper Cons. Copper Co., 31 Nassau St., New York, N. Y. '95

**GILBERT, G. K., Geologist........... U. S. Geol. Survey, Washington, D. C. '92
*GILBERT, HENDERSON, Civ. Engr...........219 Market St., Harrisburg, Pa. '02
*GILCHRIST, JOHN D., Mine Supt., Colorado Fuel & Iron Co., Boston Bldg., Denver, Colo. '96
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†GILLESPIE, T. A., Genl. Supt., Pennsylvania Co., Penn and Homewood Aves., Pittsburg, Pa. '86
†GILLET, LORENZO M., Treas., Hormiguero Central Co., 69 Wall St., New York, N. Y. '93
*GILLIE, JOHN, Supt.................Butte & Boston Con. M. Co., Butte, Mont. '87
*GILPIN, FRANCIS, Mine Mgr.............................Colorado Springs, Colo. '99
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*GIPPS, FREDERICK DEV., Min. Engr., Euriowie Tin Mines, Broken Hill, New South Wales, Australia. '94
*GIRAULT, EDMOND, Cons. Min. Engr., 2a Presidente, 1426, Mexico City, Mexico. '98
*GIROUX, EUGENE L., Min. Engr..........721 Equitable Bldg., Denver, Colo. '96
*GIROUX, JOSEPH L., Mine Mgr....................... ....Jerome, Ariz. '02
*GLASSBROOK, CLARENCE I., Mine & Mill Supt., 320 W. Hallam St., Aspen, Colo. '02
*GLEIM, FRITZ, Supt............... ....Rockhill Furnace, Rockhill, Pa. '92
*GLENN, LEONIDAS C., Prof., Geology, Vanderbilt University, Nashville, Tenn. '00
*GLENN, WILLIAM, Mgr., Baltimore Chrome Works, 1348 Block St., Baltimore, Md. '81
*GMELIN, ERNEST, Genl. Mgr., Cia. Minera de Candelaria y Anexas, Pinos, Zacatecas, Mexico. '98
*GODDARD, SYDNEY F., Min. Engr., Manor House, Bulcote, Nottinghamshire, England. '98
*GODFREY, ELI SANDFORD, Min. and Mech. Engr., 203 Broadway, New York, N. Y. '93
*GODFREY, JOHN R., Govt. Insp. of Mines, Dept. of Mines, Sydney, New South Wales. '97
†GODLEY, GEORGE MCM., Care Warren Foundry and Machine Co., 160 Broadway, New York, N. Y. '98
*GODSHALL, HARVEY H., Chem. and Min. Engr..................Lansdale, Pa. '00
*GODSHALL, L. D., Met..........................Grand Encampment, Wyoming. '94
*GOMEZ, PERFECTO, Min. Engr., Somallera Lejarza & Co., Santa Lucia, Sinaloa, Mexico. '99
*GOOD, GEORGE MCC. H., Engr. of Mines......................Osceola Mills, Pa. '87
*GOODALE, CHARLES W., Min. Engr., Asst. Mgr., Boston & Montana Con. Copper & Silver M. Co., Butte, Mont. '76
*GOODLAND, GILLMORE, Min. Engr., 109 Victoria St., Westminster, London, S. W., England. '99
*GOODLOE, MEADE, Asst. Supt., Congress Cons. M. Co., Ltd., Congress, Ariz. '96
**GOODRICH, R.R., Min. Engr., The Colonial, Wilkinsburg Sta., Pittsburg, Pa. '88
*GOODSPEED, WM. A., Supt. of Mines..........................Longacre, W. Va. '02
*GOODWIN, EDWARD, Min. Engr......................................Kenwood, Cal. '91
*GÖRANSSON, KARL F., Met.................................. .Sandviken, Sweden. '01

*Gordon, Alexander..Hamilton, Ohio. '84
*Gordon, Henry A., Civil and Min. Engr., Bank New Zealand Bldgs.,
Auckland, New Zealand. '87
*Gordon, John, Miner and Merchant, Caixa 35, Correio,
Rio de Janeiro, Brazil, So. Amer. '00
**Gordon, William D., Mining Machinery, P. O. Box 2646,
Johannesburg, Transvaal, So. Africa. '96
*Gore, James B., Assayer and Met................Hodson, Calaveras Co., Cal. '01
*Gorham, Austin G., Pres., Gorham Coal Co., Sherman M. & Millg.
Co., etc., 33 Barth Block, Denver, Colo. '81
*Gormly, Samuel J., Asst. Supt., Sampling Wks., Anaconda Copper M. Co.,
Box 32, Anaconda, Mont. '00
*Goss, Edward O., Asst. Treas............Scovill Mfg. Co., Waterbury, Conn. '94
*Gottsberger, B. Britton, Min. Engr., Care Tennessee Copper Co.,
Copperhill, Tenn. '01
*Gould, Charles J., Assayer and Surveyor, The Parral Mines, Ltd.,
Parral, Chihuahua, Mexico. '99
*Gould, Charles Newton, Prof. of Geol., University of Oklahoma,
Norman, Okla. Ty. '02
Goupilliere, Prof. Haton de la, Inspector General of Mines,
56 Rue de Vaugirard, Paris, France.
*Gouyard, Gustave M., Met..................1620 Clarkson St., Denver, Colo. '96
*Gow, P. George, Min. Mgr...............Bohemian Club, San Francisco, Cal. '99
**Grace, William F., Min. and Met. Engr., 54 York Road,
Hove, Sussex, England. '95
*Graham, Ernest, Met. Chem., Charters Towers,
North Queensland, Australia. '99
*Graham, Walter, V. Pres. and Genl. Mgr., Graham Iron Co., Graham, Va. '00
*Grammer, F. Louis.........................2422 Madison Ave., Baltimore, Md. '92
**Granger, Arthur O., Pres., Caribbean Co., and G. D. Co.,
Real Estate Trust Bldg., Philadelphia, Pa. '91
*Granger, Henry G.......................Quibdo, Choco, Colombia, S. America. '95
*Gränstrom, Gustaf A., Min. Engr.......................Karrgrufven, Sweden. '98
*Grant, Geo. H., Geol. and Min. Engr., Care Capt. Wm. Grant,
Point Ellice, Victoria, B. C., Canada. '01
*Grant, James B...777 Pearl St., Denver, Colo. '89
*Grant, Robert J., Asst. Mgr...Stratton's Independence, Ltd., Victor, Colo. '99
*Grant, Ulysses S., Prof., Geology, Northwestern University, Evanston, Ill. '01
*Grasselli, C. A.........................Grasselli Chemical Co., Cleveland, Ohio. '92
*Grave, Ernest, Mill Mgr., San Luis Mining Co., Panuco de Coronado,
Durango, Mexico. '98
*Grave, Percy, Min. Engr...................6a Victoria 62, Durango, Mexico. '98
*Graves, Fayette P., Supt. Mines.........Doe Run Lead Co., Doe Run, Mo. '92
*Graves, McDowell, Min. Engr., Compañia Mexicana,
Apartado 2032, Mexico City, Mexico. '02
*Grayson, Laurence W., Cons. Min. Eng. & Met., Ludstone Chambers,
352 Collins St., Melbourne, Victoria, Australia. '00
*Green, Charles B., Chemist...........................79 N. 4th St., Easton, Pa. '87
*Greenamyer, Arthur G., Chemist.............................Leetonia, Ohio. '02
*Greene, Francis V., Man. Dir., New Trinidad Lake Asphalt Co.,
11 Broadway, New York, N. Y. '88
*Greene, Fred. T., Min. Engr.......Anaconda Copper M. Co., Butte, Mont. '99

*GREENWAY, THOMAS J., Met., Chillagoe M. & Ry. Co., Chillagoe, No. Queensland, Australia, and 14 Sumner St., Cambridge, Mass. '95
*GREGSON, WILLIAM HILDER, Mining and Metallurgy, Broken Hill, New So. Wales, Australia. '02
*GRESLEY, WM. S., Cons. Coal Min. Engr., 115 Radbourne, Derby, England. '91
*GREY, GEORGE R., Civ. and Min. Engr., P. O. Box 777, Johannesburg, Transvaal, So. Africa. '89
*GRIER, THOMAS J., Supt................Homestake M. Co., Lead, So. Dakota. '92
*GRIFFIN, FRANK W., Pres., Western Eng. and Cons. Co., 249 Safe Deposit Bldg., San Francisco, Cal. '02
**GRIFFIN, H. M., Mine Owner............. 503 McPhee Bldg, Denver, Colo. '82
*GRIFFIN, MARTIN L., Chemist.........The Duncan Co., Mechanicsville, N. Y. '89
*Griffin, Maurice Edward, Secy., West. Eng. and Cons. Co., San Francisco, Cal. '02
*GRIFFIN, P. H., Pres....................N. Y. Car Wheel Wks., Buffalo, N. Y. '91
*GRIFFITH, CHARLES G., Min. Engr.............63 Wall St., New York, N. Y. '96
*GRIFFITHS, ANDRÉ P., Min. Engr., Genl. Mgr., of the Palmarejo and Mexican Goldfields, Ltd., Chinipas, Chihuahua, Mexico. '96
*GRIFFITHS, HARRY D., Min. and Mech. Engr., Genl. Mgr., Clarks Cons., Ltd., P. O. Box 201, Bulawayo, Rhodesia, So. Africa. '98
††GRIFFITHS, HOWARD B., Civil Engr.....2105 Boulevard, Wilmington, Del. '77
*GRIFFITHS, JOHN N.......10 So. Hyde Park Mansions, London, W., England. '00
†GRIGGS, THOMAS W., Secy. and Treas. Security Investment Co., Davenport, Iowa. '99
*GRILLO, JULIUS, Engr.............Neumühl, Hamborn, Rheinland, Germany. '96
*GRISWOLD, LEON S., Cons. Engr. and Geol., 238 Boston St, Dorchester, Mass. '00
*GRISWOLD, WILLIAM T., Topographer, U. S. Geol. Survey, Washington, D. C. '00
*GRITTINGER, HENRY C., Mgr.................Cornwall Furnace, Cornwall, Pa. '79
**GRITZNER, F. A., Chem. and Assayer...........436 E. 63d St., Chicago, Ill. '87
*GROSS, JOHN, Min. Engr...........Penobscot M. Co., Deadwood, So. Dakota. '96
*GROTHE A., Min. Engr..............................Zimapan, Hidalgo, Mexico. '86
*GRUBB, CHARLES B., Mfr. Pig-Iron ....Lancaster, Pa. '87
*GUE, T. R...Pres., Acadia Powder Co., P. O Box 520, Halifax, Nova Scotia. '89
*GUESS, HARRY A., Min. Engr ......The Silver Lake Mine, Silverton, Colo. '00
*GUINN, JOHN B., Min. Engr......................... .416 Joplin St., Joplin, Mo. '97
†GUNN, THOMAS, Contractor..............Brisbane St., Launceston, Tasmania. '01
*GWILLIM, JOHN C..Nelson, B. C., Canada. '01

*HAAS, FRANK.............................Fairmont Coal Co., Fairmont, W. Va. '97
*HAAS, HERBERT, Chem. & Met., Apartado 116, Torreon, Coahuila, Mexico. '02
*HAAS, JACOB C., Min. Engr...................So. 6th Post St, Spokane, Wash. '98
†HAASIS, ALBERT L.................Jos. Dixon Crucible Co., Jersey City, N. J. '92
*HAASIS, DUNBAR F., Supt., U. S. Govt. Harbor Improvement Plant, U. S. Steamer "Gedney," Perth Amboy, N. J. '86
*HACKETT, WM. H., Min. Engr........Person C. & G. M. Co., Durgy, N. C. '02
*HADDOCK, JOHN C......... ....1 Broadway, New York, N. Y. '91
**HADFIELD, R. A., Chairman and Man. Dir., Hadfield's Steel Foundry Co., Ltd., Hecla Wks., Sheffield, England. '89
*HAGEMANN, WILHELM, Ore Agt., Cia. Metallurgica de Torreon, Parral, Chihuahua, Mexico. '00
*HAGGEN, EDWARD A., Min. Engr....................Revelstoke, B. C., Canada. '00
*HAGGOTT, ERNEST A., Min. Engr.............................Prescott, Arizona. '02

*Haggott, Warren A. ....Idaho Springs, Colo. '01
*Hague, Arnold, Geologist ....U. S. Geol. Survey, Washington, D. C. '74
**Hahn, O. H, Min. and Met. Engr ......Care A. Hahn, Apolda, Germany. '71
*Haldeman, Horace L., Treas, Pulaski Iron Co, 330 Walnut St., Philadelphia, Pa. '86
*Hale, Irving, Elec. Engr, Mgr., Denver Office, Genl. Electric Co., Kittredge Bldg., Denver, Colo. '92
*Hall, Benjamin M., Civ. and Min. Engr., 411 Temple Court, Atlanta, Ga. '95
*Hall, Charles M., V. Pres .....Pittsburg Red. Co., Niagara Falls, N. Y. '90
*Hall, Edgar, Min. Engr. and Met., Man. Dir., Silver Spur M. Co. (of Stanhope, Queensland), Tenterfield, New South Wales. '96
*Hall, Edward J., Perth Amboy Terra Cotta Co., 15 Dey St., New York, N. Y. '76
*Hall, Everett J., Assayer.........Columbia University, New York, N. Y. '02
*Hall, Geo., Min. Engr., Mina El Carmen, El Oro, E. de Mexico, Mexico. '01
*Hall, Harry R., Lake Superior Power Co., Sault Ste. Marie, Ont., Canada. '91
*Hall, Newman G., Mine Mgr., Percy La Salle M. & P. Co., Aspen, Colo. '02
*Hall, Samson W., Min. Supt. and Mgr, Iron Mask G. M. Co., Rossland, B C., Canada. '98
*Halloran, Joseph F., Editor *Mining and Scientific Press*, 330 Market St., San Francisco, Cal. '00
*Halse, Edward, Care Señores J. M. y E. Montoya, Puerto Barrio, Colombia, So. America. '96
*Hambleton, James W., Supt. of Mines, 13 San Juan de Letran, Mexico City, Mexico. '02
*Hamilton, Charles A., Cons. and Min. Engr., Room 1209 Claus Spreckels Bldg., San Francisco, Cal. '99
*Hamilton, Frank C., Comp. Minera de Penoles, Mapimi, Durango, Mexico. '93
*Hamilton, Richard, Mine Mgr., Great Boulder Mine, Boulder, Western Australia. '98
*Hamilton, Thomas Moore, Min. Engr., 446 Lawrence St., Helena, Mont. '02
*Hammer, Alfred E., Chemist, Supt. of Works, Malleable Iron Fittings Co., Branford, Conn. '92
*Hammer, John G., Mgr...........Butte Sewer Pipe & Tile Co., Butte, Mont. '87
*Hammon, Wendell P...............Boston & Oroville M. Co., Oroville, Cal. '01
*Hammond, Isaac B., Mech. Engr., Pres., Hammond, Mfg. Co., Inc., 100 First St., Portland, Ore. '87
**Hammond, John Hays, Cons. Engr............35 Wall St., New York, N. Y. '81
*Hampton, William Huntley, Min. and Hyd. Engr., Chemist, Columbia Mines Co., Inc., Placer, Josephine Co., Ore. '90
*Hanchett, Lafayette, Mine Mgr., The Argo M., Drainage, Transportation and Tunnel Co., etc., Idaho Springs, Colo. '00
*Hancock, H. Lipson, Min. Engr., Mgr., Wallaroo & Moonta M. & Sm. Co., Ltd., Wallaroo & Moonta Mines, So. Australia. '99
*Hancock, Strangman, Min. Engr., Jumpers Deep Cleveland, Johannesburg, So. Africa. '89
*Hanks, Abbot A., Chem. and Assayer, 531 California St., San Francisco, Cal. '97
*Hanley, Herbert R., Min. Engr..................Winthrop, Shasta Co., Cal. '01
*Hanley, J. A., Jr.........................Apartado 27, Aguascalientes, Mexico. '01
*Hanna, George B., Asst. Assayer, U. S. Assay Office, P. O. Box 26, Charlotte, N. C. '87

*Hannahs, George L., Mine Mgr........................Bingham P. O., Utah. '99
*Hanson, Rasmus, Mine Owner.............. .... Eureka, Colo. '96
**Harden, Edward B., Civ. and Min. Engr., 3201 Baring St., Philadelphia, Pa. '73
**Harden, John H., Min. Engr..................P. O. Bldg., Phœnixville, Pa. '71
*Hardenbergh, William P, V. Pres., New Jersey Zinc Co., 11 Broadway, New York, N. Y. '94
*Hardenburgh, Louis M., Supt.......................Cary Mine, Hurley, Wis. '98
*Hardin, Willett L., Min. Eng. and Chemist, P. O. Box 235, Prescott, Ariz. '00
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Lesley, Prof. J. P.........Room 10, 3d Floor, 506 Walnut Street, Philadelphia, Pa.
*Leslie, Hugh M., Chem. Engr., Cyanide Process, Kolarg. Field, Marikuppam, Mysore, So. India. '97
*Letts, Robert F., Min. Engr..........334 Union, Lima, Peru, So. America. '01
**Levat, David, Min. Engr........174 Boulevard Malesherbes, Paris, France. '87
*Levings, Joseph H., Chief Assayer and Chem., Tasmania Sm. Co., Zeehan, Tasmania. '97
*Le Wald, E. A., Civil & Min. Engr.......Bond & La Farge, Seattle, Wash. '87
†Lewis, Albert.................................Bear Creek, Luzerne Co., Pa. '91

**LYMAN, BENJAMIN S., Min. Engr..........708 Locust St., Philadelphia, Pa. '71
††LYMAN, FRANK, Treas., Low Moor Iron Co. of Virginia,
Tontine Bldg., 88 Wall St., New York, N. Y. '77
*LYMAN, ROBERT, JR., Min. Engr..............................Butler, Nevada. '00
*LYMAN, ROBERT H., Spanish-American Iron Co., etc.,
Santiago de Cuba, Cuba. '96
*LYON, CHARLES G., National Mutual Bldg., Collins St.,
Melbourne, Victoria, Australia. '97
*LYON, DORSEY A..Address wanted. '98
†LYSLE, WALTER SCOTT, Metallurgical Engr.,
354 West 120th St., New York, N. Y. '02

*McARTHUR, ROBERT A., Min. Engr.,
Parrott Silver & Cop. Co., Butte, Mont. '00
*McCAFFERY, RICHARD S., Min. Engr.....120 Broadway, New York, N. Y. '95
*McCALLEY, HENRY, Chem.......................................University, Ala. '88
†McCALLUM, A. CAMPBELL, Min. Engr........P. O. Victoria, B. C., Canada. '02
†McCALLUM, WILLIAM H., Mech. Engr...925 Chestnut St, Philadelphia, Pa. '84
*McCANDLESS, E. V., Accountant..................P. O. Box 1096, Pittsburg, Pa. '79
*McCANN, FERDINAND, Min. Engr.............Cadereyta, Queretaro, Mexico. '02
*McCARTHY, EDWARD E., Min. Engr.........43 Irving St., Cambridge, Mass. '00
*McCARTHY, EDWARD T., Gen. Mgr., Matheson & Co.,
3 Lombard St, London, England. '97
*McCARTHY, M. E., Min. Engr......1025 South 19th St., Birmingham, Ala. '97
*McCARTNEY, ROBERT J., Mill Supt...............................Silverton, Colo. '97
*McCARTY, GEO. J., Mine Mgr.........................Torres, Sonora, Mexico. '01
*McCAY, DR. LE ROY W., Prof. of General Chemistry, Princeton Univ.,
Princeton, N. J. '85
*McCHRYSTAL, J. C................................P. O. Box "F," Eureka, Utah. '01
*McCLELLAN, ARTHUR....................................Drifton, Luzerne Co., Pa. '71
*McCLINTOCK, WILLIAM H., Mine Operator..........................Sonora, Cal. '98
*McCLURE, DAVID, Mine Supt...................Gwinmine, Calaveras Co., Cal. '00
*McCLURE, SAMUEL, Genl. Mgr., Stewart Iron Co., Ltd.,
Sharon, Mercer Co, Pa. '91
*McCLURG, JAMES A., Min. Engr.........938 Equitable Bldg., Denver, Colo. '98
*McCOMAS, WILLIAM P., Mine Supt....................Beverly, Sierra Co., Cal. '01
*McCONNELL, JOHN, Nova Scotia Steel Co., 3604 Powelton Ave.,
Philadelphia, Pa. '96
*McCONNELL, NEVIN..................................Union Steel Co., Donora, Pa. '94
*McCORD, WILLIAM H..Sandy, Nevada. '99
*McCORMACK, G. B., V. Pres...........Woodward Iron Co., Woodward, Ala. '91
*McCORMICK, EDWARD, Min. Engr...........1564 Hecla St., Calumet, Mich. '97
*McCORMICK, HENRY, JR...........Central Iron & Steel Co., Harrisburg, Pa. '92
*McCORMICK, VANCE C., Secy. and Treas., Sonman Shaft Coal Co.,
Harrisburg, Pa. '94
*McCOY, JAMES W., Cons. Min. Engr., Montana Cop. & G. M. Co.,
125 La Salle St., Chicago, Ill. '97
*McCREATH, ANDREW S., Chem................223 Market St., Harrisburg, Pa. '75
*McCREATH, LESLEY, Chemist..................223 Market St., Harrisburg, Pa. '02
*McCREE, PARRINGTON M., Mine Supt........Box 1027, Salt Lake City, Utah. '99
*McCRERY, CHARLES, Genl. Supt., Dominion Iron & Steel Co., Ltd.,
Sydney, Cape Breton, Nova Scotia. '89

*McCulloch, Richard, Asst. Gen. Mgr., Chicago City Ry. Co., 2020 State St., Chicago, Ill. '91
*McCullough, Edmund H., Pres., Westmoreland Coal Co., 224 So. 3d St., Philadelphia, Pa. '01
*McCurdy, John E.......................Apartado 2217, Mexico City, Mexico. '97
*McDaniel, Alex. K., Min. Engr.........107 So. Excelsior St., Butte, Mont. '02
*McDermott, Walter, Min. and Met. Engr., 43 Threadneedle St., London, E. C., England. '74
*McDonald, Jno. A., Care McDonald, Searles & Co, 4 Chapel St., Cripplegate, London, E. C., England. '01
*McDonald, Joseph A., Supt., Ohio Wks., National Steel Co., Youngstown, Ohio. '00
*McDonald, Samuel, Supt., Bessemer Dept., Republic Iron & Steel Co., Youngstown, Ohio. '85
*McDonald, Thomas, Genl. Supt.....National Steel Co., Youngstown, Ohio. '90
*McDowell, J. C...................................812 Frick Bldg., Pittsburg, Pa. '94
*McGary, E. L., Consulting Engr., Rooms 1214–17, Westinghouse Bldg., Pittsburg, Pa. '94
*McGee, George T., Min. Engr................Anaconda M. Co., Butte, Mont. '99
*McGrath, John, Mine Mgr.....................Apartado 22, Oaxaca, Mexico. '02
*McGregor, J. Murray, M. E. and Provincial Land Surveyor, Slocan, B. C, Canada. '01
*McHose, Arthur...............................Boone Clay Works, Boone, Iowa. '99
*McIlvain, Edward M., Pres...Bethlehem Steel Co., South Bethlehem, Pa. '86
†McIlvain, J. Gibson, Lumber Merchant, 58th St. and Woodland Ave., Philadelphia, Pa. '01
*McIlvain, William R., Pres., Reading Gas. Co., 210 North 5th St., Reading, Pa. '92
*McKay, John R., Mining Accountant, Lake View Consols, Ltd., Boulder, Western Australia. '94
*McKee, Jas. A., Supt. Mach. Dept., Cia. Fundidora de Fierro y Acero, Monterey, N. L, Mexico. '02
*McKee, John F., Mine Supt.......................Baker Mines, Carroll Co., Va. '92
*McKenna, Alexander G., Met., Chemist, Firth Sterling Steel Co, Demmler, Pa. '96
*McKenna, Charles F., Chem. Engr.........221 Pearl St., New York, N. Y. '94
*McKeown, W. W., Chem..................829 Wick Ave., Youngstown, Ohio. '00
**McKillop, John, Met. Engr., 3 Clements Inn, Strand, London, W. C., England. '93
*McKinley, Wm. B., Min. Engr..........108 W. 79th St., New York, N. Y. '02
†McKinney, R. C..............................136 Liberty St., New York, N. Y. '86
*McLanahan, J. King, Iron Mfr. and Miner................Hollidaysburg, Pa. '81
*McLean, Gordon, Min. Engr..Morenci, Ariz. '99
*McLean, John H., Supt.................Oliver Iron M. Co., Ironwood, Mich. '00
*McLeavy, John, Mine Mgr.......John McLeavy & Co., Punxsutawney, Pa. '75
*McLennan, J. S........Dominion Coal Co., Ltd., 95 Milk St., Boston, Mass. '85
*McLure, Charles D., Min. Engr.........608 Security Bldg., St. Louis, Mo. '88
*McMahan, Charles H., Genl. Supt., Sombrerete M. Co., Sombrerete, Zacatecas, Mexico. '95
*McMurray, Max, Genl. Supt., Newburg Wks., American Steel & Wire Co., Cleveland, Ohio. '02
*McNamara, Herbert H......................316 Torrey Bldg., Duluth, Minn. '02

*McNaugher, David W., Civil Engr., Robert W. Hunt & Co.,
Monongahela Bank Bldg., Pittsburg, Pa. '96
*McNulty, Samuel G..............Superior C. S. & H. R. R., Calf Creek, Ky. '02
*McVichie, D., Supt. of Mines, De la Mars Mercur Mine Co., Mercur, Utah. '91
*MacArthur, John S., Met................45 Renfield St., Glasgow. Scotland. '92
*MacCallum, N. G., Supt., Steel Plant, Phœnix Iron Co , Phœnixville, Pa. '02
*Macco, Heinrich, Civil and Met Engr........................Siegen, Germany. '92
*MacCulloch, Charles, Min. Engr., Fir Grove,
Gladstone Road, Auckland, New Zealand. '98
*MacDonald, Bernard......................P. O. Drawer 1747, Spokane, Wash. '89
*Macdonald, Charles, Civil Engr.............2 Wall Street, New York, N. Y. '75
*MacDonald, Jesse J., Min. Engr., Care Inca Min. Co.,
Tirapata, Peru, So. America. '00
*Macdonald, Joseph, Mine Mgr., Alaska Treadwell S. M. Co.,
Douglas Island, Alaska. '96
*MacDonald, Michael E., Mine Manager,
P. O. Box 33, Guanajuato, Mexico. '02
*MacDonald, William T., Min. Engr., 128 No. Main St., Los Angeles, Cal. '01
*MacFarlane, George, Min. Engr., Les Compagnie Française de Mines
d'Or et d'Exploration, 20 Rue Taitbout, Paris, France. '98
*Macfarlane, Graham, Pres..................3d & Main Sts, Louisville, Ky. '86
*MacFarlane, Rienzo W, Care Dupp Syndicate,
Singapore, Malay Peninsula. '02
*Macfarlane, Thomas, Chief Analyst, Inland Revenue Laboratory,
317 Queen St., Ottawa, Canada. '89
*MacGeorge, Alexander J., Min. Engr.,
P. O. Box 240, Kalgoorlie, Western Australia. '97
*Mack, Thomas A , Mgr , Furnace and Mine,
508 Neave Bldg., Cincinnati, Ohio. '88
*Mackay, Angus, Min. Engr. and Met.................... Douglas City, Alaska. '87
*Mackay, Angus R., Chem.......................Royal Bldg , Montreal, Canada. '96
*Mackay, Philip A., Care Sulphide Corp. Co. of London & Australia,
Cockle Creek, New So. Wales, Australia. '99
*Mackay, Walter, Mining...............320 Montgomery St., Portland, Ore. '87
*Mackenzie, G. S., Met., Sydney Sm. Co.......Woolwich, New South Wales. '87
*Mackenzie, Louis, Mech. Engr., Riverside Dept., National Tube Co.,
Wheeling, W. Va. '96
*Mackey, Perry D., Republic Iron & Steel Co.............Youngstown. Ohio. '94
*MacKinnon, G. W. W., 2 East India Ave., Leadenhall St.,
London, E. C., England. '93
*MacLeod, Wm. Alex., Director, School of Mines,
Charters Towers, Queensland, Australia. '01
*MacLeod, William A , Min. Engr., P. O. Box 222, Sudbury, Ont , Canada. '99
*MacNaughton, James, Pres. & Treas., MacIntyre I. Co.,
26 Cortlandt St., New York, N. Y. '93
*MacNaughton, James, Min. Engr., Genl. Mgr., Calumet & Hecla Mines,
Calumet, Mich. '90
**MacNeill, Charles M., Vice-Pres and Genl. Mgr., U. S. Reduction &
Ref. Co., etc., Colorado Springs, Colo. '99
*Macnutt, Charles H., Min. Engr., Cia. Huanchaca de Bolivia,
Pulacayo, Bolivia, So. America. '90
*Macomb, John de N., Jr., Civil Engr., 1417 Kentucky St., Lawrence, Kas. '00

*MacPherran, Ralph S., Chem.... ...Allis-Chalmers Co., Milwaukee, Wis. '97
*Magenau, Wm., Supt... ....Catherine Lead Co., Fredericktown, Mo. '02
*Magruder, William T., Prof. Mech. Engr., Ohio State Univ ,
Columbus, Ohio. '88
*Mahony, Arthur S. J...........................51 W. 94th St., New York, N.Y. '88
*Main, Alfred F., Asst Genl Mgr., El Oro M. & Ry Co., Ltd.,
El Oro, Mexico, Mexico. '02
*Mainwaring, Hugh M. C., Min. Surveyor, Care Chillagoe Ry. & Mines,
Ltd., Chillagoe, Queensland, Australia. '99
*Maitland, George C., Min. Engr.,
Brookman St., Kalgoorlie, Western Australia, '00
*Makita, Tamaki, Min. Mgr., Care Mitsui Müke Coal Mines,
Chikugo, Japan. '00
*Malcolmson, James W., Cons. Min. Engr., P. O. Box 327, El Paso, Texas. '90
*Malins, Francis A., Min. Engr...P. O. Box 296, Silver City, New Mexico. '97
*Malm, J. Lawrence, Genl. Mgr., Electro-Chemical Ore Reduction Co.,
Marysville, Mont. '96
*Manley, Frank Austin, Chief Eng., Union Pacific Coal Co.,
P. O. Box 165, Rock Springs, Wyo. '02
*Manley, Henry L., Min. Engr., Crows' Nest Pass. C. Co.,
Fernie, B. C., Canada. '93
*Mann, James S., Assayer and Chem., Univ. of Arizona...Tucson, Arizona. '02
*Mann, William S.........Thayer M. & M. Co., Miramar, Costa Rica, C. A. '01
*Mannesmann, Robert........... ....Remscheid, Germany. '90
*Mannheim, Ernest A., Min. Engr., Care Howells Explor. Co.,
Gundagai, New South Wales. '01
*Mannheim, H. C., Chemist, Min. Engr., 76 Warren St., New York, N.Y. '89
*Mannheim, P. A. L., Met., and Asst. Supt. Am. S. & R. Co.,
Monterey, Mexico. '89
*Mansfield, Nathan T.. ... Address wanted. '96
*Manson, William O., Mining.................Equitable Bldg., Denver, Colo. '02
*Marais, Emile M. C. Du, Min. Engr.,
6 Quai de l'Amerante, St. Petersburg, Russia. '96
*Markle, Alvan, Coal Mine Operator...............................Hazleton, Pa. '85
*Markle, John, Min. Engr.......................G. B. Markle & Co., Jeddo, Pa. '79
**Marriner, Jno. T., Engr., East Murchison United G. M.,
Lawlers, East Murchison, W. Australia. '01
*Martin, Dr. A. A., Min. Engr...Unter den Linden 8, Berlin, W. Germany. '00
**Martin, Edward P., Civil Engr., Genl. Director of Guest Keen Co , Ltd.,
Dowlais, Glamorganshire, Wales. '81
*Martin, J. B., Supt., Bessemer Steel Dept., Penn. Steel Co ,
Box 42, Steelton, Pa. '86
*Martin, J. F.............................Phœnix Foundry, Gawler, S. Australia. '93
*Martin, Nicholas J., Supt. of Mines, N.Y. & Honduras Rosario M. Co.,
San Juancito, Honduras, Central America. '00
*Martin, Simon S., Supt., Steel Dept., Maryland Steel Co.,
612 C St., Sparrows Point, Md. '99
*Martinez, Adolfo, Cia. Metallurgica Mexicana...San Luis Potosí, Mexico. '02
*Mason, Russell T., Min. Engr..............Care E. C. Mason, Boulder, Colo. '93
*Massenez, Joseph, Engr..........10 Humboldtstrasse, Wiesbaden, Germany. '91
*Masters, Harris K., Smelter Supt.,
Care U. S. Min. Co., Salt Lake City, Utah. '95

*MATCHAM, CHARLES A., Genl. Mgr., Lehigh Portland Cement Co.. Allentown, Pa. '97
*MATHER, HENRY A., Secy., Verde Queen Cop. Co. of Arizona, etc., 41 Cortlandt St., New York, N. Y. '00
*MATHER, SAMUEL.......... ....Richards, Mather & Co., Cleveland, Ohio. '79
†MATHER, WILLIAM G., Pres.......Cleveland Cliff Iron Co., Cleveland, Ohio. '86
*MATHESON, WILLIAM G., Mgr., I. Matheson & Co , Ltd., New Glasgow, Nova Scotia. '85
*MATHEWS, EDWARD J............................71 Broadway, New York, N. Y. '97
**MATHEWSON, E. P., Met........Anaconda Copper M. Co., Anaconda, Mont. '89
*MATTERN, HERMAN, Min. Mgr....................................Hornbrook, Cal. '02
*MATTES, CHARLES C., Min. Engr.........615 Lackawanna Ave., Scranton, Pa. '81
*MATTES, WILLIAM F., Cons. Engr.................Connell Bldg., Scranton, Pa. '81
*MATTHIESSEN, F. W............Matthiessen & Hegeler Zinc Co., La Salle, Ill. '84
*MAUNEY, A. C., Cashier............Whitney Reduction Co., Gold Hill, N. C. '94
*MAURICE JOSEPH, Min. Engr., Monte Horcaz's Domain, por Villanueva-Minas, Province of Seville, Spain. '90
*MAURICE, JUAN, Min. Engr ....Potosi, Bolivia, So. America. '00
*MAXSON, CHESTER W., Supt.........M. M. M. Co., Ltd., Lordsburg, N. Mex. '02
*MAXWELL, JNO. W. C., Min. Engr....320 Sansome St., San Francisco, Cal. '02
**MAY, ALBERT EDWARD, Reduction Office, Care Latham G. M. Co., Ltd., Caethé-Minas Geraes, via Rio de Janeiro, Brazil, So. America. '02
*MAY, DE COURCY, Genl. Mgr.........N. Y. Shipbuilding Co., Camden, N. J. '79
**MAY, JESSE J., Mine Mgr..............Alma G. M. Co., Idaho Springs, Colo. '01
*MAYNARD, GEORGE W., Min. and Metl. Engr., 20 Nassau St., New York, N.Y. '71
*MAYNARD, REA E., Civil Engr............ ..P. O Box 721, Honolulu, Hawaii. '94
*MAYO, JAMES H., Coal Operator...Paramaribo, Dutch Guiana, So. America. '82
*MEAKER, W. LATHROP, Chemist, Spanish-Amer. Iron Co., Daiquiri, Santiago de Cuba, Cuba. '00
*MEANS, ELLISON C., Pres. and Gen. Mgr., Low Moor Iron Co. of Va., Low Moor, Va. '88
*MEANS, JOHN H., Min. Engr., Care Bewick, Moreing & Co., 20 Copthall Ave , London, E. C , England. '97
*MEEKER, DAVID M., Foundry Supt., Care S J. Meeker, 95 Clay St., Newark, N. J. '91
*MEEKS, REGINALD, Metallurgical Engr., Griffin Wheel Co.....Chicago, Ill. '02
*MEGRAW, HERBERT A., Met., Guanajuato Cons. M. & M. Co., Apartado 33, Guanajuato, Mexico. '01
*MEIER, EDWARD D., Pres. and Chief Engr., Heine Safety Boiler Co., 11 Broadway, New York, N. Y. '86
*MEIN, WILLIAM W., Mgr., Durban Roodeport Deep, Ltd , Box 110, Roodeport, Transvaal, So. Africa. '00
*MEISSNER, CARL A., Min. Engr., Dominion I. & S. Co., Sydney, C. B., Nova Scotia. '00
*MEISTER, HERMAN C............................2930 Geyer Ave., St. Louis, Mo. '77
*MELLA, FRITZ..Keystone, S. Dakota. '01
*MELLISS, D. ERNEST, Cons. Min. and Civ. Engr., 208 California St., San Francisco, Cal. '00
*MELZER, GUSTAV E., Min. Engr. and Met.......Bourne, Baker Co., Oregon. '00
*MERCER, JOHN W., Genl. Mgr., So. American Development Co., P. O. Box 336, Guayaquil, Ecuador, and 15 Broad St., New York, N. Y. '97
*MERCER, WILLIAM A., Min. Engr., Bloomfield House, 85 London Wall, London, E. C., England. '92

*MERCUR, ROBERT S., Div. Supt......Lehigh Valley Coal Co., Centralia, Pa. '00
*MERRICKS, FRANK, Min. Engr., 5 Great Winchester St., London, E. C., England. '92
*MERRILL, CHARLES W., Met.................Homestake M. Co., Lead, So. Dak. '92
*MERRILL, EDWARD P., Genl. Supt.......U. S. Coal Oil Co., Logan, W. Va. '01
*MERRILL, FREDERICK J. H., State Geologist, New York State Museum, Albany, N. Y. '85
*MERRY, HENRY G, Genl. Mgr......Montana Coal & Coke Co., Horr, Mont. '89
†MERRYWEATHER, GEORGE, Genl. Western Agt., Coxe Bros. & Co., Inc., 601 The Rookery, Chicago, Ill. '80
*MESSITER, EDWIN H, Supt. of Construction, Care Federal Lead Co., 705 Olive St., St. Louis, Mo. '01
*MESSLER, EUGENE L., Genl. Supt., Blast Furnace & Coke Wks., Jones & McLaughlin, Ltd., Pittsburg, Pa. '97
*METCALF, ALFRED T., Genl. Mgr., United Reefs (Sheba), Ltd., Eureka, Transvaal, S. Africa. '91
*METCALF, ORLANDO, Treas.................Verona Tool Works, Pittsburg, Pa. '79
*METCALF, WILLIAM.....................................1 Fulton St., Pittsburg, Pa. '94
*METCALFE, G. W., Genl. Smelter Foreman, Anaconda Cop. M. Co., Anaconda, Mont. '96
*MEYER, A. R..........................403 New England Bldg., Kansas City, Mo. '86
*MIDDLETON, W. B., Min. Engr., 671 Salisbury House, London Wall, London, E. C., England. '92
*MILLEN, LORING R.............................149 Broadway, New York, N. Y. '01
*MILLER, ALFRED S., Prof. of Mining, Met. and Geology.. .Moscow, Idaho. '98
*MILLER, CHARLES L., Genl. Supt., Am. Steel & Wire Co., Tradesmen Bldg., Pittsburg, Pa. '93
*MILLER, CHARLES W., Min. Engr.........Denver Athletic Club, Denver, Colo. '84
*MILLER, D. IRVING, Supt. of Furnace Division, Tenn. Coal, Iron & R. R. Co., Sheffield, Ala. '02
*MILLER, EDMUND H., Prof. of Anal. Chem. and Assaying, Columbia Univ., New York, N. Y. '95
*MILLER, HARRY E..............................331 Pine St., San Francisco, Cal. '01
*MILLER, HARRY H., Min. Engr., Met. and Chem., Balzac Valley Co., 13 Park Row, New York, N. Y. '95
*MILLER, HARRY W., Cons. Engr., Atlas Engine Wks, Capetown, So. Africa. '92
*MILLER, JAMES, Supt., Saô Bento Gold Estates, Ltd., Minas Geraes, Brazil, So. America. '95
*MILLER, JOHN, Min. Engr.......6 Woodlands, Langside, Glasgow, Scotland. '97
*MILLER, JOSEPH, Mine Supt., Golden Age Cons, Ltd., Wiliena, Lake Way, Western Australia. '99
*MILLER, LEONARD B., Iron Ore. Oglebay, Norton & Co., 67 Wade Bldg., Cleveland, Ohio. '93
*MILLER, SPENCER, Mech. Engr...............96 Liberty St., New York, N. Y. '90
*MILLER, W. CLAYTON, Min. Engr, Mgr., Empire State-Idaho Min. and Dev. Co., Wardner, Idaho. '95
*MILLER, WILLIAM P., JR., Met., Selby Sm. & Lead Co., 416 Montgomery St., San Francisco, Cal. '93
*MILLS, CHARLES E., Supt., Detroit Cop. M. Co., of Arizona..Morenci, Ariz. '90
*MILLS, EUGENE C., Min. Engr.................................Minot, N. Dakota. '01
*MILLS, FRANK P., Supt....................Merced G. M. Co., Coulterville, Cal. '83
*MILLS, LOUIS D..................................P. O. Box 91, Lead, So. Dakota. '01

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*MINEHAN, MICHAEL M., Assayer ....Gabriel, Durango, Mexico. '98
*MINGAYE, JOHN C. H., Analyst, Chem. Laboratory, Dept. of Mines, Sydney, New South Wales. '91
*MITCHELL, D. P., Min. Engr......Care Bewick, Moreing & Co., Auckland, New Zealand. '97
*MITCHELL, GEORGE, Met..................Greene Cons. Cop. Co., Naco, Ariz. '99
*MITCHELL, PENTECOST, Mine Supt.................................Hibbing, Minn. '97
*MITCHELL, ROBERT, Miner and Shipper of Coal, The North American Bldg., Philadelphia, Pa. '86
*MITCHELL, WALTER K., Blast Furnace Specialties, W. K. Mitchell & Co., Betz Bldg., Philadelphia, Pa. '92
*MITCHENER, CHARLES E., Min. Engr................New Philadelphia, Ohio. '99
*MITINSKY, ALEXANDER N., Prof. of Mining, Academy of Empress Catherine II., St. Petersburg, Russia '00
*MIXER, CHARLES T., Chem...Park City, Utah. '97
*MIXSELL, PHILIP, Min. and Milling......1266 Downing Ave., Denver, Colo. '02
*MOEN, PHILIP W., 3d Vice-Pres., Amer. Steel and Wire Co., Worcester, Mass. '82
*MOFFAT, A. D..........Granite Bi-metallic Cons. M. Co., Philipsburg, Mont. '88
*MOFFAT, JOHN..........................Irvinebank, No. Queensland, Australia. '02
*MOHR, LOUIS, Secy. and Cons. Engr...............32 Illinois St., Chicago, Ill. '88
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*MOLSON, CHARLES A., Cons. Engr., Exploration Co., Ltd., Dooly Bldg., Salt Lake City, Utah. '87
*MONELL, AMBROSE, Pres., International Nickel Co., 74 Broadway, P. O. Box 1325, New York, N. Y. '02
*MONELL, JOSEPH T..............................Flat River, St. François Co., Mo. '81
*MONTAGU, RALPH L., Supt., Power Plant, Union G. D. Co., Centerville, Idaho. '01
**MONTGOMERY, ALEXANDER, Min. Engr. & Geol., State Mining Engr. Dept. of Mines, Perth, Western Australia. '94
*MOODY, BURDETT, Civil & Mining Engr., with Homestake M. Co., Lead, So. Dakota. '96
*MOORE, CHARLES J., Min. Engr..........P. O. Box 548, Cripple Creek, Colo. '82
*MOORE, CLINTON H., Mining.................328 East Broadway, Butte, Mont. '94
*MOORE, GEORGE, Agent, Amer. Sm. & Ref. Co., 135 So. 11th St., East, Salt Lake City, Utah. '97
*MOORE, MARSHALL G., Min. Engr.........Cambria Steel Co., Johnstown, Pa. '86
*MOORE, MILTON J., Chief Chem........Ill. Steel Co., Joliet Wks., Joliet, Ill. '98
*MOORE, PHILIP N., Cons. Min. Engr. and Geol., 121 Laclede Bldg, St. Louis, Mo. '74
*MORGAN, CHARLES H.. ....21 Lincoln St., Worcester, Mass. '74
*MORGAN, JOSEPH, Chief Engr..............Cambria Steel Co., Johnstown, Pa. '81
*MORISON, GEORGE S., Civil Engr...........49 Wall Street, New York, N. Y. '79
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Columbia University, New York, N. Y. '97
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538 Sacramento St., San Francisco, Cal. '89

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P. O. Box 20, Monterey, Mexico. '02

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Kensington, London, W., England. '81
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131 Wyoming Ave., Scranton, Pa. '87
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High Bridge, N. J. '75
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Haile Gold Mine, S. C. '78
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109 Victoria St., Westminster, London, S. W., England. '92
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27 William St., New York, N. Y. '91
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1105 Penn Sq. Bldg., Philadelphia, Pa. '80
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Umtali, Rhodesia, So. Africa. '01
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610 Harrison Bldg, Philadelphia, Pa. '79
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Bozeman, Mont. '99
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*Wagner, John L., Pres....Wagner Palenros Mfg. Co., Fairmont, W. Va. '00
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*Walker, Arthur L., Mgr., Perth Amboy Plant, Amer. Sm. & Ref. Co., Maurer, N. J. '85
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Launceston, Tasmania. '94
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Am. Sm. & Ref. Co., El Paso, Texas. '02
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P. O. Box 158, Kalgoorlie, W. Australia. '98
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Rockwood, Tenn. '92
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M. and Dev. Co., Ltd, Princeton, B. C., Canada. '95
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Perth, Western Australia. '98
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*Watson, Robert W., Min. Mgr., Iowa G. M. and Milling Co.,
Silverton, Colo. '00
*Watson, Rolla B., Cons. Min. Engr., 233 Commercial Club Bldg.,
Salt Lake City, Utah. '95
*Watson, Prof. Thos. L......................Denison Univ., Granville, Ohio. '01
*Watson, Walter L., Genl. Mgr. & Engr., Clear Spring Water Co.,
Cementon, Pa. '98
*Watson, Winfield S. ....Sandy Lake, Pa. '01

*WATT, J. HENRY.................................First Natl. Bank, Braddock, Pa. '97
*WATTS, WILLIAM L., Min. Engr, State Expert of Mines,
Chamber of Commerce, Los Angeles, Cal. '97
†WAUGH, PERCIVAL B., Min. Engr..The Glen, Bournemouth, West England. '90
*WEATHERBY, WM. J., Min Engr................................Cooney, N. Mexico. '02
*WEBB, ERNEST H.............................Care Trenton I. Co., Trenton, N. J. '01
**WEBB, HARRY H., Supt. Engr., Care Cons. Gold Fields, Ltd.,
P. O. Box 1167, Johannesburg, Transvaal, S. Africa. '85
*WEBB, LOUIS, Care Dev. Co. of C. & W. Africa, 23 Moorfields,
London, E. C, England, '97
*WEBB, WILLIAM M., Min. Engr., Ibex M. Co.,
P. O. Box 307, Leadville, Colo. '00
*WEBER, FREDERICK C., Mech. Engr., Rand Drill Co.,
710 Park Bldg., Pittsburg, Pa. '99
*WEBSTER, HOSEA, Mgr. N. Y. Sales Dept., Babcock & Wilcox Co.,
85 Liberty St., New York, N. Y. '95
*WEBSTER, PAUL W., Min. Engr....Variety Iron Wks. Co., Cleveland, Ohio. '98
**WEBSTER, WILLIAM R., Cons. and Insp. Engr., 411 Walnut St,
Philadelphia, Pa. '92
*WECK, CHARLES A., Min. Engr., 127 New Montgomery St.,
San Francisco, Cal. '97
Wedding, Prof. Dr. Hermann, Prof. of Iron Metallurgy, Counsellor of
Mines, Genthinerstrasse 13, Villa C., Berlin, Germany.
*WEDDLE, JOSEPH H., Mine Mgr...............Vinnse M. Co., Leadville, Colo. '97
*WEDGE, UTLEY, Miner and Oil Refiner..115 Chestnut St., Philadelphia, Pa. '02
*WEED, FLOYD, Met. and Chem......Annie Laurie M. Co., Kimberly, Utah. '97
*WEED, WALTER H., Cons. Min. Engr., U. S. Geol. Survey, Washington, D. C. '98
**WEIGALL, ALFRED R., Met. Engr, Care Japan M. Co., Ltd.,
Yokohama, Japan. '98
*WEIMER, ASA A., Mech. Engr....Weimer Machine Wks. Co., Lebanon, Pa. '85
†WEIMER, EDGAR A., Supt...........Weimer Machine Wks. Co., Lebanon, Pa. '97
*WEIMER, JOHN A., Pres. and Supt., Weimer Machine Wks. Co.,
Lebanon, Pa. '85
**WEINBERG, E. A., Genl. Mgr., Chillagoe Ry. & Mines, Ltd.,
Chillagoe, No. Queensland, Australia. '94
*WEIR, CHARLES G., Mining..............................Highland, Ulster Co., N. Y. '95
*WEIR, GEORGE, Chief Engr., Broken Hill Prop Co., Block 14 Mine,
Broken Hill, New South Wales. '00
*WEIR, THOMAS, Min. Engr., Owner & Mgr. of Mines,
Room 306, Dooly Block, Salt Lake City, Utah. '90
*WEISS, MORITZ, Met.................................324 Cedar Ave., Scranton, Pa. '91
*WELD, CHRISTOPHER M., Min. Engr., Mine Securities Corp.,
35 Wall St., New York, N. Y. '01
*WELLMAN, CHARLES H., Genl. Mgr., Wellman Seever-Morgan Engineering
Co., New England Bldg., Cleveland, Ohio. '90
**WELLMAN, SAMUEL T., Pres., Wellman Seaver Engineering Co.,
New England Bldg., Cleveland, Ohio. '75
†WELLS, CALVIN, Mfr..............Pittsburg Forge and Iron Co., Pittsburg, Pa. '73
*WELLS, HORACE L., Prof. Chem. and Met., Sheffield Scientific School,
New Haven, Conn. '95
*WELLS, J. WALTER, Min. Engr., Provincial Assay Office,
Belleville, Ont., Canada. '02

*WELSH, HOWARD F., State Inspector Coal Mines, Lock Box 855,
Helena, Mont. '91
*WENDEL, CHARLES DE, Engr..............6041 Bond St., E E., Pittsburg, Pa. '00
*WENSTROM, OLAF, Min. Engr........................45 Broad St., Boston, Mass. '88
*WENTZ, JOHN L., Coal Mining.........1100 Girard Trust Bldg., Phila., Pa. '02
*WENTZ, JOHN S., Coal Operator.............39th and Locust Sts., Phila., Pa. '02
*WEPFER, G. W., Cons. Mech. Engr., P. O. Box 2088, Johannesburg,
Transvaal, So. Africa. '99
*WESLEY, WM. H. J.........Mt. Lyell M. & R. Co., Queenstown, Tasmania. '01
**WEST, HAARLEM E., Min. Mgr., Pacific Northwest M. Corp., Ltd.,
Libby, Mont. '00
*WESTERN, CHARLES R., Engr., Broadway Chambers, Westminster,
London, England. '92
*WESTERN, FRANK, Min. Engr..6 Bolton Gardens, S. W., London, England. '95
**WESTERVELT, WILLIAM Y., Cons. Min. Engr., 100 William St.,
New York, N. Y. '95
*WESTINGHOUSE, GEORGE, JR., Mech. Engr...........................Pittsburg, Pa. '86
**WETHERILL, JOHN P., Cons. Engr., New Jersey Zinc Co.,
11 Broadway, New York, N. Y. '96
*WETHEY, A. H., Genl. Mgr....W. A. Clark's Mines & Smelter, Butte, Mont. '90
*WETMORE, E. A.................................P. O. Box 131, Marysville, Mont. '89
*WHEELER, ARCHER E., Chief Engr., Boston & Montana C. C. and S. M. Co.,
Great Falls, Mont. '99
**WHEELER, HERBERT A., Cons. Min. Engr.....721 Olive St., St. Louis, Mo. '81
*WHEELER, S. BOWMAN, Mech. Engr.....Girard Trust Bldg., Philadelphia, Pa. '92
*WHEELER, SHELTON KING, Assayer and Min. Engr.,
30 W. 44th St., New York, N. Y. '02
*WHINERY, S., Civil Engr.........................95 Liberty St., New York, N. Y. '80
†WHIPPLE, ARTHUR S.........P. O. Box 332, Melbourne, Victoria, Australia. '99
*WHITAKER, DE BERNIERE, Min. Engr., Spanish-American Iron Co.,
Daiquiri, Santiago de Cuba. '99
*WHITAKER, ORVILLE R., Min. Engr., N. Y. & Honduras Mining Co.,
San Juancito, Rep. Honduras, C. A. '99
*WHITCOMB, GEORGE D., Pres., G. D. Whitcomb Co.,
86 East Ohio St., Chicago, Ill. '83
*WHITE, CHARLES H., Instructor Min. & Met.,
Rotch Bldg., Cambridge, Mass. '01
*WHITE, MAUNSEL, Chem...Bethlehem, Pa. '88
†WHITE, NORMAN F., Min. Engr.....Mount Morgan, Queensland, Australia. '02
*WHITEHEAD, CABELL, Assayer................Riggs House, Washington, D. C. '90
*WHITELEY, JAMES S...................Continental Trust Bldg., Baltimore, Md. '92
*WHITING, S. B. ....11 Ware St., Cambridge, Mass. '71
*WHITMORE, LAWRENCE H., Civil, Mech. & Mining Engr.,
P. O. Box 163, Bulawayo, Rhodesia, So. Africa. '90
*WHITNEY, ELI, JR.........................800 Whitney Ave., New Haven, Conn. '75
*WHITNEY, GRANGER, La Follette Coal, Iron & R.R. Co.,
La Follete, Tenn. '91
*WHITNEY, WILLIS R., Electro Chem., Genl. Elec. Co., Schenectady, N. Y. '02
*WHITTALL, HUGH E. C., Min. Engr., Care J. W. Whittall & Co.,
via London Open Mail, Constantinople, Turkey. '99
*WHITTLE, CHARLES L., Geol. and Min. Engr..20 Central St., Boston, Mass. '97
*WHYTE, FREDERICK W. C., Genl. Mgr. of Coal Dept.,
Anaconda Cop. M. Co., Anaconda, Mont. '00

*WIARD, EDWARD S., Assayer, Empire State Idaho M. & Dev. Co.,
Wardner, Idaho. '00
*WICKES, GEORGE T., Civil and Min. Engr.,
Rooms 34 & 35 Pittsburg Block, Helena, Mont. '76
†WICKES, L. WEBSTER, Student............Columbia Univ., New York, N. Y. '02
*WIDDICOMBE, HERBERT F., Min. Engr..........................Whitehall, Mont. '98
*WIERUM, HOWARD F., Chem.....................Colo. Sm. Co., Durango, Colo. '98
*WIGMORE, CYRIL, Min. Engr..117 South Los Angeles St., Los Angeles, Cal. '00
†WILBRAHAM, ARTHUR G. B., Mine Supt., Mason & Barry,
Mina de San Domingos, Mertola, Portugal. '99
*WILBUR, WARREN A., Pres., Valley Coal & Coke Co., W. Va.,
South Bethlehem, Pa. '92
*WILCOX, JOHN F., Genl. Mgr. and Chief Engr., Retort Coke Oven Co.,
New England Bldg., Cleveland, Ohio. '86
*WILDER, FRED. B., Min. Engr.........................P. O. Box 543, Reno, Nev. '02
*WILDING, JAMES, JR., Chem., Amer. Smelting & Ref. Co.
Aguascalientes, Mexico. '96
*WILES, EDWIN L...............................Stony Point, Rockland Co., N. Y. '82
**WILEY, WALTER H., Min. Engr..... ....Idaho Springs, Colo. '96
*WILEY, WILLIAM H., Publisher...43 East Nineteenth St., New York, N. Y. '81
*WILEY, WILLIAM M., Pres., Seminole Mining Co.,
25 Broad St., New York, N. Y. '00
*WILKENS, HENRY A. J., Min. Engr., New Jersey Zinc Co.,
11 Broadway, New York, N. Y. '92
*WILKES, JOHN, Mgr..................Mecklenburg Iron Wks., Charlotte, N. C. '83
*WILKINS, ALBERT D., Chem....................P. O. Box 324, Vandergrift, Pa. '02
*WILKINS, ROSS, Chemist, The Solvay Process Co., 621 Jefferson Ave.,
Detroit, Mich. '86
*WILKINS, WILLIAM, Supt. Blast Furnace, National Tube Co.,
Riverside Dept., Wheeling, W. Va. '91
*WILKINS, WILLIAM GLYDE, Min. Engr...Westinghouse Bldg., Pittsburg, Pa. '91
**WILKINSON, ARTHUR, Min. Engr., Care H. Eckstein & Co.,
Johannesburg, So. Africa. '00
*WILKINSON, CHARLES D., Min. Engr.............................Whitehall, Mont. '97
*WILKINSON, J. F., Min. Engr., Care W. J. Bartnett, 328 Montgomery St.,
San Francisco, Cal. '90
*WILKINSON, PAUL, Secy., Acme Cement Plaster Co.,
917 Century Bldg., St. Louis, Mo. '97
*WILKINSON, THEODORE K., Met., 1407 Van Ness Ave., San Francisco, Cal. '96
**WILKINSON, WILLIAM F., Min. Engr., Consolidated Goldfields of
So. Africa, 8 Old Jewry, London, E. C., England. '88
*WILLARD, EUGENE B., JR., Blast Furnace Mgr., Iroquois Iron Co.,
95th St. & Calumet River, Chicago, Ill. '00
*WILLEY, HENRY I., Min. Engr............27 William St., New York, N. Y. '02
**WILLIAMS, ALPHEUS F., Asst. Genl. Mgr., De Beers Cons. Mines, Ltd.,
Kimberley, So. Africa. '97
*WILLIAMS, BEN, Mine Mgr..Milton, Cal. '82
*WILLIAMS, DAVID, Publisher, *Iron Age*, 238 William St., New York, N. Y. '80
*WILLIAMS, EDWARD G., Engr. and Supt, Caribbean Manganese Co.
(temporary, cor. Maple & Central Sts., Auburndale, Mass.),
Colon, Colombia, So. America. '97
*WILLIAMS, EDWARD H., Mgr., Blast Furnaces, Pickands Mather & Co.,
499 E. State St., Sharon, Pa. '93

*WILLIAMS, PROF. E. H., Jr..Andover, Mass. '76
*WILLIAMS, FRANK B., Mill Supt.........Elkhorn S. M. Co., Elkhorn, Mont. '01
**WILLIAMS, FRED, Man. Dir, Waratah Minerals Co., 7 Laurence, Pountney Lane, London, E. C., England. '99
*WILLIAMS, FRED. T., Min. Engr...................P. O. Box 86, Victor, Colo. '02
**WILLIAMS, GARDNER F., Genl. Mgr., De Beers Cons. Mines, Ltd., 62 Lombard St., London, E. C., England. '86
*WILLIAMS, HENRY J., Chem. Engr. and Anal Chem., 161 Tremont St, Boston, Mass. '87
*WILLIAMS, H. J. C., Min. Engr, Care W. A. Trelvan, Chilicito Rioja, Argentine Republic, So. America. '93
*WILLIAMS, JOHN R., Cons. Met. and Chem., Care H. Eckstein & Co., P. O. Box 149, Johannesburg, Transvaal, So. Africa. '99
*WILLIAMS, JOHN T., Constructing Engr. ....27 William St., New York, N. Y. '74
*WILLIAMS, LEWIS...................................Napoleon Mine, Milton, Cal. '83
*WILLIAMS, LUKE, Genl. Mgr., Mount Reid M. Co., Ltd., Mount Read, Tasmania. '93
*WILLIAMS, MORRIS, Mgr., Coal Cos., P. R. R., 67 Public Square, Wilkes-Barre, Pa. '91
*WILLIAMS, OLIVER, Pres..............Bryden Horse Shoe Co., Catasauqua, Pa. '87
*WILLIAMS, RICHARD H., Min. Engr., Chynoweth, St. Erth Hall, Cornwall, England. '96
*WILLIAMS, SAMUEL H., Genl. Mgr., Br. & Korean Corp, Ltd., Care Jardine, Matheson & Co., Shanghai, China, '95
*WILLIAMS, THOMAS J., Min. Engr., Colebrooke Cop. Mine, Montezuma, Tasmania. '98
*WILLIAMSON, W. DUNCAN...Lily Bank, Gowrock Rd., Greenock, Scotland. '96
*WILLIS, ALFRED B., Min Engr........32 Cornhill, London, E. C., England. '02
*WILLIS, BAILEY, Geol....................U. S. Geol. Survey, Washington, D. C. '92
*WILLIS, FRANK G., Min. Engr., Mining Exchange Bldg., Cripple Creek, Colo. '97
*WILLMOTT, ARTHUR B., Geol., Algoma Coml. Co., Sault Ste. Marie, Ont., Canada. '01
*WILLS, JOSEPH L., Min. Engr. and Chem..133 Midwood St., Brooklyn, N. Y. '89
*WILLSON, FREDERICK E., Min. Engr.....2117 Taylor St., San Fancisco, Cal. '98
*WILSON, ALBERT D., U. S. Deputy Mineral Survey, P. O. Box 611, Deadwood, So. Dak. '97
*WILSON, ELLIOTT H., Civil and Min. Engr., Receiver, Minnie Healy Mine, Butte, Mont. '87
*WILSON, ELWOOD J., Mining Operator..............Greenwood, B. C., Canada. '94
*WILSON, GEORGE B., Min. Engr., Cons. Engr. for Chinese Engineering & M. Co., Ltd., Tientsin, China. '99
**WILSON, GORDON...............................Benallan, Kirkintilloch, Scotland. '02
*WILSON, HARRY, Austral Otis Engineering Co., Ltd., So. Melbourne, Australia. '93
†WILSON, M. O., Mnfr. and Miner............33 Wall Street, New York, N. Y. '91
*WILSON, NATHANIEL, Cons. Mech. Engr., P. O. Box 485, Johannesburg, Transvaal, So. Africa. '98
**WILSON, NEWTON R., Genl. Mgr......27 Calle Iturbide, Monterey, Mexico. '81
**WILSON, RICHARD, Min. Mgr............Mammoth M. Co., Wallace, Idaho. '00
†WILSON, R. T., JR., Mnfr. and Miner.......33 Wall Street, New York, N. Y. '91
*WILSON, WILLIAM A., Cons. Min. Engr., 610 Progress Bldg., Salt Lake City, Utah. '83

*WILSON, WALTER B., Min. Engr............Box 453, Colorado Springs, Colo. '92
*WILTSEE, E. A., Chem..............850 Equitable Trust Bldg., Denver, Colo. '86
*WINCHELL, ALEX. N...........................State School of Mines, Butte, Mont. '01
*WINCHELL, HORACE V., Geol...........Anaconda Cop. M. Co., Butte, Mont. '92
*WINES, JERRY M., Miner.......................P. O. Box 783, El Paso, Texas. '01
*WINGATE, HAMILTON M., Chem. and Met., Glenthorpe, Cotham Grove,
Bristol, England. '95
*WINMILL, HALLETT, Min. Engr.,
P. O. Box 217, Coolgardie, Western Australia. '98
*WINSLOW, ARTHUR, Min. Engr. and Geol., Liberty Bell G. M. Co.,
308 Lyceum Bldg., Kansas City, Mo. '81
†WINSLOW, GEORGE C., JR..................107 Huntington Ave., Boston, Mass. '97
*WISEMAN, PHILIP, Mgr...................2313 So. Hope St., Los Angeles, Cal. '98
*WISHON, WALTER W., Min. Engr.....................................Butte, Mont '82
*WISTER, JONES, Dealer in Pig Iron, Coal & Coke,
672 Bullitt Bldg., Philadelphia, Pa. '79
*WITHERBEE, FRANK S., Iron Mining.........................Port Henry, N. Y. '76
**WITHERBEE, T. F., Supt., Mexican National Steel & Iron Co.,
Durango, Mexico. '71
*WITHERBEE, WALTER C., Iron Business, Treas., Witherbee, Sherman & Co.,
Port Henry, N. Y. '80
*WOAKES, ERNEST R., Cons. Min. Engr.,
78 Harley St., London, W. England. '89
*WOLF, ALBERT H., Cons. and Contracting Engr., Room 720 218 LaSalle St.,
Chicago, Ill. '82
*WOLF, THEODORE G...........................136 Wyoming Ave., Scranton, Pa. '79
**WOLFF, DR. FR. M....................2 Jaegerstrasse, Berlin, West Germany. '82
*WOLLE, HARTLEY C., Asst. Supt., Besssemer Mills, Cambria Steel Co.,
Johnstown, Pa. '86
**WOO YANG TSANG, Mine Mgr., Tong Colliery,
Tong Shan, near Tientsin, China. '00
*WOOD, ALVINUS B., Min. Engr., Treas., Welded Steel Barrel Co.,
30 Medbury Ave., Detroit, Mich. '82
*WOOD, A. HAMILTON, Vice-Pres. and Genl. Mgr., Crooked Fork Coal
& Coke Co., Petros, Tenn. '97
*WOOD, E. FRED., Vice-Pres., International Nickel Co.,
74 Broadway, New York, N. Y. '86
*WOOD, E. SEYMOUR, Chief Min. Engr., Bengal Coal Co., Ltd.,
5 Fairlee Place, Calcutta, India. '97
*WOOD, HOWARD, Pres.......................Alan Wood Co., Conshohocken, Pa. '88
*WOOD, LEE S., Mine Mgr.............................203 23d Ave., Denver, Colo. '96
*WOOD, ROBERT A., Mine Engr...18 Queen Victoria St., London, E. C., Eng. '97
*WOOD, THOMAS D., Iron Mnfr..............82 Vandergrift Bldg., Pittsburg, Pa. '79
*WOOD, TINGLEY L., Mining....... ....Leadville, Colo. '89
*WOOD, WALTER, Iron Mnfr.............400 Chestnut Street, Philadelphia, Pa. '85
*WOOD, WILLIAM O., Mgr., By-Product Coke Ovens, Semet-Solvay Co.,
Benwood, W. Va. '00
**WOODBRIDGE, TYLER R., Mgr. Taylor & Brunton Sampling Co.,
Victor, Colo. '87
*WOODBURY, LEANDER S., Pres..Great Falls Iron Works, Great Falls, Mont. '80
*WOODROW, JAMES W., Genl. Supt., Comp. Minera de Peñoles,
Mapimi, Durango, Mexico. '95

*Woods, Frank M., Mine Mgr..Victor, Colo. '98
**Woodward, Allan H., Genl. Supt...Woodward Iron Co, Woodward, Ala. '00
*Woodward, Henry E., Mine Supt.........Percy Cons. M. Co., Aspen, Colo. '89
*Woodworth, Todd C., Mine Supt............................Lake Linden, Mich. '99
**Woolmer, Herbert C T., Genl. Mgr. Waitekauri Extended, Ltd.,
Maratoto, Auckland, New Zealand. '98
*Worthington, Charles C., Mech. Engr..120 Liberty St., New York, N. Y. '85
*Wright, Cary, Mining.......... ....Capitol Hotel, Boise, Idaho. '00
*Wright, Fred. A., Mining ....Apartado 89, Monterey, N. L., Mexico. '02
*Wright, James N., Mine Supt., retired, 34 Warren Ave., E. Detroit, Mich. '79
*Wright, Lewis T., Genl. Mgr. and Supt. Engr., Mountain Cop. Co.,
Keswick, Cal. '97
†Wright, Philip E., Sales Agt.........703 Girard Bldg., Philadelphia, Pa. '02
*Wright, Sidney B, Met., Care Ponsonby & Bolton, 48 Queen St.,
Melbourne, Australia. '00
**Wright, Whitaker...........2 Whitehall Court, London, S. W., England. '81
*Wright, William Q., Min. Engr......320 Sansome St., San Francisco, Cal. '99
*Wrightson, Wilfrid I., Min. Engr...Neasham Hall, Darlington, England. '00
*Wrinkle, L. F. J., Min. Engr..............Riverside Hotel, Reno, Nevada. '01
*Wuensch, Alfred F., Min. Engr.............1220 Corona St., Denver, Colo. '00
**Würgler, André, Min. Engr., Prof. of Mining,
7 Rue Viète, Paris, France. '85
*Wulff, Christian S., Mgr.......................Stuttenheim, C. C., So. Africa. '98
*Wyatt, Francis, Chem.....................39 S. William St., New York, N. Y. '87
**Wynne, Ashley H. P., Assayer, Care Calabacillas Mining Co.,
via San José de Gracia, Sinaloa, Mexico. '95

*Yamanūchi, Shigema, Cons. Engr. to Takata & Co.,
Kojîmachi-Ku, Tokio, Japan. '98
*Yard, Henry H., Min. Engr............415 Drexel Bldg., Philadelphia, Pa. '98
*Yeates, William S., State Geol..Atlanta, Ga. '95
*Yeatman, Pope, Genl. Mgr, Randfontein Estates & G. M. Co.. Ltd.,
Randfontein, Transvaal, So. Africa. '83
*Yonge, Allen M., Min. Engr., Thayer M. & M. Co., Miramar
(via New Orleans), Costa Rica, Central America. '00
*York, James E., Cons. Engr....................52 Broadway, New York, N.Y. '87
*Yorke, Charles A., Min. Engr..52 Rutland Gate, S.W., London, England. '98
*Young, Edward L., Engineer, Takata & Co..10 Wall St, New York, N.Y. '87
†Young, Francis E., V. Pres., Boston Exploration Co.,
20 Central St., Boston, Mass. '02
**Young, George J., Asst. Prof. of Met....Univ. of Nevada, Reno, Nevada. '00
*Young, James S., Met.....................51 Grant Street, Glasgow, Scotland. '95
*Young, John C., Miner..Baker City, Ore. '02
*Young, John W., Secy., Allis-Chalmers Co., 25 Broad St.,
New York, N. Y. '94
*Young, J. W. R, Strathmore, Eastern Road, East Finchley, N.,
London, England. '91
*Young, Lewis E...P. O. Box 19, Ames, Iowa. '01
*Yung, Morrison B., Assayer and Min. Engr., 748 Asylum Ave.,
Hartford, Conn. '02

*Zambrano, Adolpho, Miner..................P. O. Box 6, Monterey, Mexico. '02
*Zehnder, C. H.....................................25 Broad St., New York, N. Y. '87

*ZELLER, FRANK M., Secy., Continental Mfg. Co., 400 Chestnut St., Philadelphia, Pa. '00
*ZERBEY, FREDERICK E., Min. Engr..........38 North Vine St., Hazleton, Pa. '92
*ZIMMERMAN, ADOLPH A., Chemist and Assayer..................Helena, Mont. '96
†ZINTGRAFF, E............................Hoboken-les-Anvers, Antwerp, Belgium. '98

Honorary Members	10
Members	3100
Associates	157
Total	3267

Deceased.

Addy, Matthew	1896
Allen, R. B.	1896
Amiot, H.	1892
Amsler, Carl	1894
Ångström. Carl	1901
Armstrong, John F.	1898
Arnolds, Hugo	1886
Ashburner, Charles Albert	1889
Ashburner, William	1887
Atkins, C. M., Jr.	1885
Ayers, William	1898
Babcock, Geo. H.	1893
Bailey, Edward	1889
Bailey, Jackson	1887
Barnes, F. W.	1892
Barns, George T.	1900
Barratt, D. H.	1888
Batterman, C. S.	1901
Becher, H M.	1893
Beeger, H.	1892
Bell, G. B.	1893
Bennett, David A.	1897
Bierwith, L. C.	1902
Billing, G.	1890
Blake, F. C.	1891
Blossom, T. M.	1876
Boericke, Rudolph	1897
Booth, Edgar H.	1898
Borda, E.	1897
Bosher, C. H.	1894
Bowden, James H.	1900
Bowman, Amos	1894
Boyle, Thomas G.	1890
Braden, S.	1894
Brainerd, A. F.	1893
Bramwell, J. H.	1894
Briggs, Robert	1882
Brinsmade, J. B.	1884
Brown, A. C.	1890
Brown, A. J.	1875
Browne, Arthur Richard	1900
Browning, F. D.	1885
Bruckner, Wm.	1887
Brunings, J. H.	1893
Bucke, M. A.	1899
Buell, P. A.	1900
Bullock, M. C.	1899
Bunsen, Robert	1887
Butler, Cyrus	1890
Button, Edward	1900
Byers, Alexander M.	1900
Caldwell, W. B., Jr.	1880
Cameron, James R.	1881
Campbell, William Y.	1899
Carkeek, John	1900
Carnegie, Thomas M	1886
Carpenter, J. H.	1898
Carrel, F. J.	1894
Carroll, Michael	1891
Cary, John S.	1899
Case, W. H.	1898
Castillo, A. del	1895
Chalfant, John W.	1898
Chambers, R. C.	1901
Chanute, Arthur	1895
Chaper, Maurice	1896
Cheever, B. W.	1888
Chisholm, Henry	1881
Chisholm, S. S.	1901
Clark, C. J.	1896
Clark, Ellis	1895
Clark, Henry G.	1881
Clark, R. Neilson	1894
Clark, William	1884
Clayton, Joshua	1889
Clayton, W. S.	1886
Clemes, J. P.	1876
Cole, Harold M.	1902
Collins, Arthur L.	1902
Collins, H. E.	1896
Conant, T. P.	1891
Conro, Albert	1901
Contreras, Manuel Maria	1902
Converse, James B.	1883
Conyngham, C. M.	1894
Cook, George H.	1886
Corbett, Francis E.	1901
Coryell, Martin	1892
Cowland, C. D.	1894
Cowles, E. H.	1892
Coxe, Eckley B.	1895
Crafts, Walter	1896
Craven, Frank S.	1889
Craven, Henry S.	1889
Crocker, William B.	1885
Curry, Henry M.	1900
Daddow, S. H.	1875
Dagron, J. G.	1895
D'Aligny, H. F. Q.	1875
Darley, E. C.	1901
Darling, J. V.	1892
Darling, W. P.	1896
Daubrée, A.	1896
Davidson, D. R.	1884
Davies, Edw. S.	1885
Davies, W. B.	1891
Davis, M. C.	1886
Dayton, L. M.	1892
De Camp, A. H.	1895
De Camp, Edw. F.	1895
De Crano, E. G.	1893
De Peiger, R. F. J.	1883
Desloge, John M.	1900
Dickson, Thomas	1884
Disston, Horace C.	1902
Disston, Thomas S.	1895
Dodge, Wallace H.	1895
Dodson, R. T.	1896

Dominick, F. J.	1895	Harvey, William H.	1888
Dorsey, E. B.	1900	Hayden, Edward S.	1899
Dresser, Charles A.	1873	Hazard, Rowland	1898
Duffield, P. W.	1897	Healy, Morris	1881
Durfee, W. F.	1899	Heard, John, Jr.	1895
Dwight, W. S.	1884	Hemphill, James	1900
Egleston, Thomas	1900	Heinrich, Oswald	1886
Ely, E. B.	1884	Henry, Adolph	1892
Ely, George H.	1894	Hicks, Geo. J.	1891
Emanuel, W. H.	1901	Hillman, Daniel	1890
Emerson, B. F.	1884	Hinton, F.	1895
Emery, Charles E.	1898	Hoatson, Thomas	1897
Engelmann, Henry	1899	Hodgson, Thomas	1896
Escobar, Mario	1901	Hoefer, Eugene	1899
Essery, E. H.	1897	Holbrook, F. N.	1902
Evans, John D.	1891	Holden, E. F.	1899
Fegeley, Isaac	1891	Holley, A. L.	1882
Felton, S. M.	1884	Hollister, O. J.	1892
Fernekes, Anton	1887	Holloway, J. F.	1896
Ferris, G. W. G.	1896	Hopke, Frank E.	1890
Firmstone, William	1875	Horton, N. W.	1886
Fisher, Harvey	1889	Hosie, James P.	1898
Fisher, H. H.	1888	Hosking, George F.	1895
Foote, Herbert C.	1880	Howard, T.	1896
Ford, Robert G.	1891	Huhn, E. C. O.	1894
Francis, A. G.	1890	Hulbert, Thomas H.	1889
Freeman, H. C.	1900	Humphreys, A. W.	1894
French, Aaron	1902	Hunt, Alfred E.	1899
Fuller, John T.	1885	Hunt, Joseph	1897
Fuller, T. E.	1898	Hunt, Joshua	1886
Fulton, G. E.	1895	Hunt, Thomas	1872
Furlonge, W. H.	1896	**Hunt, T. Sterry**	1892
Furman, H. Van F.	1902	Hussey, C. C.	1884
Gaetzschmann, Moritz	1895	Hyndman, E. K.	1884
Gatewood, R.	1890	Ingersoll, S. Warren	1884
Gibson, W. K.	1898	Inman, A. L.	1894
Gilbert, Edward G.	1893	Ireland, Thomas A.	1902
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Hall, Isaac	1902	Jousselin, A. L.	1897
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Stevens, Edwin A	1902
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Swoyer, John H	1899
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Taunton, F. W	1900
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Thomson, John L	1900
Thonard, Leon	1886
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Torrance, J. F	1895
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Ulrich, George H. F	1900
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Van Tuyll, C. B	1890
Van Wickle, A. S	1898
Van Zandt, F	1892
Veeder, H	1896
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Walker, Joseph R	1901
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Walsh, Edward, Jr	1901
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Walz, Isidor	1877
Warner, L. E	1884
Waters, J. H. E	1893
Waters, Thomas J	1898
Watson, Frederick M	1900
Watson, Wm	1902
Watts, D	1893
Webb, H. Walter	1900
Weeks, Joseph D	1896
Weir, Robert S	1898
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Wells, Bard	1893
Wendel, Dr. A	1881
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West, A. R	1893
Wheatley, Charles M	1882
Wheeler, Moses D	1889
Wheelock, Jerome	1902
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Whitaker, Thomas D	1896
White, James B	1887
Whyte, John S	1902
Wiestling, G. B	1891

Wilcox, S.	1893
Williams, Frank	1901
Williams, Henry	1902
Williams, J. J.	1892
Wilson, J. A	1896
Wilson, J. W.	1894
Wister, John	1900
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Wood, James G.	1899
Wood, W. Dewees	1899
Wood, Wm. J.	1885
Woodford, Clarence A.	1898
Worthington, Henry R.	1880
Wright, Charles E.	1888
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Wrigley, H. E	1882
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Yardley, Thomas W.	1900
Young, James B.	1902

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* Annual meeting for the election of officers. The rules were amended at the Chattanooga meeting, May, 1878, changing the annual election from May to February.

† Begun in May at Easton, Pa., for the election of officers, and adjourned to Philadelphia.

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* Annual meeting for the election of officers.

† Begun in February at New York City, for the election of officers, and adjourned to Florida.

‡ " " " " " " " " " " " " " to Philadelphia.

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RULES

ADOPTED MAY, 1873. AMENDED MAY, 1875, 1877, AND 1878, FEBRUARY, 1880, 1881, 1887, 1890, AND 1896.

I.

OBJECTS.

THE objects of the AMERICAN INSTITUTE OF MINING ENGINEERS are to promote the arts and sciences connected with the economical production of the useful minerals and metals, and the welfare of those employed in these industries, by means of meetings for social intercourse, and the reading and discussion of professional papers, and to circulate, by means of publications among its members and associates, the information thus obtained.

II.

MEMBERSHIP.

The Institute shall consist of Members, Honorary Members, and Associates. Members and Honorary Members shall be professional mining engineers, geologists, metallurgists, or chemists, or persons practically engaged in mining, metallurgy, or metallurgical engineering. Associates shall include all suitable persons desirous of being connected with the Institute, and duly elected as hereinafter provided. Each person desirous of becoming a member or associate shall be proposed by at least three members or associates, approved by the Council, and elected by ballot at a regular meeting (or by ballot at any time conducted through the mail, as the Council may prescribe) upon receiving three-fourths of the votes cast, and shall become a member or associate on the payment of his first dues. Each person proposed as an honorary member shall be recommended by at least ten members or associates, approved by the Council, and elected by ballot at a regular meeting (or by ballot at any time conducted through the mail, as the Council may prescribe) on receiving nine-tenths of the votes cast; *Provided*, that the number of honorary members shall not exceed twenty. The Council may at any time change the classification of a person elected as associate, so as to make him a member, or *vice versa*, subject to the approval of the Institute. All members and associates shall be equally entitled to the privileges of membership; *Provided*, that honorary members shall not be entitled to vote, and members or associates whose post-office address shall be outside of the United States, Canada and Mexico shall not be entitled to vote by mail, except upon proposed amendments to the Rules.

Any member or associate may be stricken from the list on recommendation of the Council, by the vote of three-fourths of the members and associates present at any annual meeting, due notice having been mailed in writing by the Secretary to the said member or associate.

III.

DUES.

The dues of members and associates shall be ten dollars, payable upon their election, and ten dollars per annum thereafter, payable in advance on the first day of each calendar year. Honorary members shall not be liable to dues. Any member or associate not in arrears may become by the payment of one hundred dollars at one time a life-member or associate, and shall not be liable thereafter to annual dues. Any member or associate in arrears may, at the discretion of the Council, be deprived of the receipt of publications, or stricken from the list of members when in arrears for one year; *Provided*, that he may be restored to membership by the Council on payment of all arrears, or by re-election after an interval of three years.

IV.

OFFICERS.

The affairs of the Institute shall be managed by a Council, consisting of a President, six Vice-Presidents, nine Managers, a Secretary and a Treasurer, who shall be elected from among the members and associates of the Institute at the annual meetings, to hold office as follows:

The President, the Secretary, and the Treasurer for one year (and no person shall be eligible for immediate re-election as President who shall have held that office subsequent to the adoption of these rules, for two consecutive years), the Vice-Presidents for two years, and the Managers for three years; and no Vice-President or Manager shall be eligible for immediate re-election to the same office at the expiration of the term for which he was elected. At each annual meeting a President, three Vice-Presidents, three Managers, a Secretary, and a Treasurer shall be elected, and the term of office shall continue until the adjournment of the meeting at which their successors are elected.

The duties of all officers shall be such as usually pertain to their offices, or may be delegated to them by the Council or the Institute; and the Council may in its discretion require bonds to be given by the Treasurer. At each annual meeting the Council shall make a report of proceedings to the Institute, together with a financial statement.

Vacancies in the Council may occur by death or resignation; or the Council may, by a vote of the majority of all its members, declare the place of any officer vacant, on his failure for one year, from inability or otherwise, to attend the Council meetings or perform the duties of his office. All vacancies shall be filled by the appointment of the Council, and any person so appointed shall hold office for the remainder of the term for which his predecessor was elected or appointed; *Provided*, that the said appointment shall not render him ineligible at the next annual meeting.

Five members of the Council shall constitute a quorum; but the Council may appoint an Executive Committee, or business may he transacted at a regularly called meeting of the Council, at which less than a quorum is present, subject to

the approval of a majority of the Council, subsequently given in writing to the Secretary, and recorded by him with the minutes.

V.

ELECTIONS.

The annual election shall be conducted as follows: Nominations may be sent in writing to the Secretary, accompanied with the names of the proposers, at any time not less than thirty days before the annual meeting; and the Secretary shall, not less than two weeks before the said meeting, mail to every member or associate (except honorary members) a list of all the nominations for each office so received, together with a copy of this rule, and the names of the persons ineligible for election to each office; and if the Council, or a Committee thereof, appointed for the purpose, shall have recommended any nominations, such recommendation may also be sent to members and associates with the said list of all nominations made, but not upon the same paper. And each member or associate, qualified to vote, may vote, either by striking from or adding to the names of the said list, leaving names not exceeding in number the officers to be elected, or by preparing a new list, signing said altered or prepared ballot with his name, and either mailing it to the Secretary or presenting it in person at the annual meeting; *Provided*, that no member or associate in arrears since the last annual meeting shall be allowed to vote until the said arrears shall have been paid. The ballots shall be received and examined by three Scrutineers, appointed at the annual meeting by the presiding officer; and the persons who shall have received the greatest number of votes for the several offices shall be declared elected, and the Scrutineers shall so report to the presiding officer. The ballots shall be destroyed, and a list of the elected officers, certified by the Scrutineers, shall be preserved by the Secretary.

VI.

MEETINGS.

The annual meeting of the Institute shall take place on the third Tuesday of February, at which a report of the proceedings of the Institute and an abstract of the accounts shall be furnished by the Council. Other meetings shall be held in each year, at such times and places as the Council shall select, and notice of all meetings shall be given by mail, or otherwise, to all members and associates, at least twenty days in advance.

Every question which shall come before any meeting of the Institute, shall be decided, unless otherwise provided by these Rules, by the votes of a majority of the members then present. Any member or associate may introduce a stranger to any meeting; but the latter shall not take part in the proceedings without the consent of the meeting.

VII.

PAPERS AND PUBLICATIONS.

The Council shall have power to decide on the propriety of communicating to the Institute any papers which may be received, and they shall be at liberty, when they think it desirable, to direct that any paper read before the Institute shall

be printed in the *Transactions*. Intimation, when practical, shall be given, at each general meeting, of the subject of the paper or papers to be read, and of the questions for discussion at the next meeting. The reading of papers shall not be delayed beyond such hour as the presiding officer shall think proper; and the election of members or other business may be adjourned by the presiding officer, to permit the reading and discussion of papers. The published papers and volumes of *Transactions* shall be distributed to all members and associates not in arrears, and may be sold to the public upon such conditions as the Council shall prescribe; but the Council may, in its discretion, omit sending to members and associates outside of the United States, Canada and Mexico, special circulars, unless the same contain proposed amendments to the Rules.

The copyright of all papers communicated to, and accepted by, the Institute, shall be vested in it, unless otherwise agreed between the Council and the author. The author of each paper read before the Institute shall be entitled to twelve copies, if printed, for his own use, and shall have the right to order any number of copies at the cost of paper and printing, provided said copies are not intended for sale. The Institute is not, as a body, responsible for the statements of fact or opinion advanced in papers or discussions at its meetings, and it is understood that papers and discussions should not include matters relating to politics or purely to trade; nor shall the Council or the Institute officially approve or disapprove any technical or scientific opinion or any proposed enterprise outside the management of the meetings, discussions and publications of the Institute, as provided in these Rules; *Provided*, however, that committees may be appointed by the Council or the Institute to make investigations and submit reports at meetings of the Institute; but no action shall be taken binding the Institute for or against the conclusions of any such reports.

VIII.

AMENDMENTS.

These Rules may be amended at any annual meeting by a two-thirds vote of the members present; *Provided*, that written notice of the proposed amendment shall have been given at a previous meeting; *and Provided, also*, that the amendment or amendments so adopted shall be printed upon a ballot and sent, not later than the next distribution of printed matter, to all members and associates not in arrears for the preceding year (except honorary members and foreign members elected before February, 1880), and each person receiving the same shall be requested to return it to the Secretary with his written vote of Yes or No to each amendment, and his signature; and the President shall appoint as Scrutineers three members or associates, who shall examine all of the said ballots which shall have been returned within one month from the date of their distribution, and shall report the result; and the Secretary shall publish and distribute to members, not later than the next distribution of printed matter, an announcement of the said result so reported, together with the text of the additional or amended rule or rules so adopted; and the amendment or amendments approved by the majority of the ballots so returned and reported shall become part of these Rules from and after the publication of said announcement by the Secretary.

Proceedings of the Eighty-First Meeting, Mexico, November, 1901.

HONORARY PRESIDENTS OF ENTERTAINMENT COMMITTEES.

Hon. Leandro Fernández, *Minister of Fomento.*
Hon. José Ives Limantour, *Minister of Finance.*
Hon. Justino Fernández, *Minister of Justice and Public Instruction.*
Hon. Guillermo de Landa y Escandón, *Mayor of the City of Mexico.*
Carlos F. de Landero, E.M., C.E., *Vice-President of the Institute.*

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Local Committee of Guadalajara.—Gabriel Castaños, *President;* Ignacio Guavara, *Vice-President;* Ambrosio Ulloa, *Secretary;* Gabriel Castillo, Ignacio Guavara, Juan José Matute, Mariano Schiaffino, Daniel V. Navarro, Rafael de la Mora; also the members of the Society of Engineers and leading merchants and bankers.

Local Committee of Guanajuato.—Ponciano Aguilar, Joaquin Parres, Roberto Fernandez, L. M. Cockerell, Manuel L. Ajuria, Pío R. Alatorre, Rámon Alcázar, Manuel Antillón, Manuel Aranda, Manuel Balarezo, G. W. Bryant, Andres Bravo, Juan Castelazo, Ernesto Castelazo, Rodrigo Castelazo, Francisco Castro, Ricardo Chico, Juan N. Contreras, Cornelio Cornejo, Alex. J. Cumming, Eduardo Cumming, Amado Delgado, Dwight A. C. Furness, Jesús Fernández, Juan M. Garma, Enrique Glennie, Ricardo A. Glennie, Luis Göerne, Vicente González, Felipe González, Ignacio Ibargüengoitia, Ignacio A. Lozano, Enrique Medina, M. E. McDonald, Enrique Martinez, G. W. McElhiney, Pablo Orozco, Pablo Parkman, Fernando Parkman, Samuel A. Parkman, José A. Pesquera, Ignacio Rocha, Atanasio Rocha, Carlos Robles, Francisco Reynoso, Eusebio Rojas, Luis Silva, Amado Saavedra, Ignacio Sánchez.

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The first session was held in the Hall of Councils of the School of Engineers,* in the City of Mexico, on Saturday evening, November 9.

Engineer Don Augustin Aragon, in behalf of the Minister of *Fomento*,† the Society of Engineers and Architects, the Academy of Science, and the National School of Engineers, delivered in Spanish an address of welcome, which was repeated in English by Mr. Victor M. Braschi, President of the Local Committee, as follows:

"*Members of the American Institute of Mining Engineers:*

"Owing to the fact that I have the rare good fortune to belong to the Society of Engineers and Architects and to the Academy of Physical and Natural Science,

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* The School of Engineers, formerly the School of Mines, is the oldest technical educational institution in America. It was organized by Don Joaquin Velazquez Cardenas y Leon, the first classes being opened in 1792. In 1813 the present imposing structure was completed. The central vestibule gives access to a magnificent open patio or court, surrounded by arches, four minor courts furnishing light and ventilation to the other departments. The central part of the structure alone is occupied by the National School of Engineers, which is very well equipped. In the main entrance and in front of the principal stairway are the three famous Mexican meteorites found in the State of Chihuahua, the largest weighing over 14 tons.

It is worthy of mention that the beautiful Hall of Councils had been so recently completed that the sessions of the Institute, held therein, practically constituted its most appropriate dedication to the purposes for which it was designed.

† This comprehensive term can scarcely be expressed by an English synonym. Perhaps the nearest would be "Encouragement"; in fact, the department of the Republic bearing this title has charge of matters relating to the promotion of national industries, and is analogous, though not exactly similar, to the U. S. Department of the Interior.

to the further fact that I have received my professional education in the National School of Engineers, and that I belong to the staff of employés of the Department of Fomento, I have been entrusted, in the name and on behalf of all the above-named institutions and of the Minister of Fomento, with the honorable and gratifying duty of welcoming you upon your arrival in this capital, where we hope and desire that you may be welcomed with the cordial hospitality to which you are entitled as the representatives of a famous and meritorious organization.

"We hope that your visit to this country may not only be pleasant to you by reason of our fine climate, our beautiful scenery and historical associations, but also instructive in the science and art which are your specialty, and which, by your perseverance, your energy, and your ability, you have carried in the United States to an astonishing degree of perfection.

"Undoubtedly travel and excursions form an important factor of education and amusement. To the engineer they are also a source of economic utility, inasmuch as, by visiting new localities and new countries, he is enabled to judge personally of industrial methods, of the progress of applied science, and the conditions of life among his professional brethren who may be more, or perhaps less, favored by fortune than he; and if, among the faculties which he has cultivated, he possesses that of observation, he receives from travel a practical lesson of the most varied and useful kind.

"We hope that beneath the perfect skies of our fatherland you will find not only the rest to which your active lives in your homes beyond the Bravo entitle you, but also food for instructive reflection suggested by the contrast between that which you are about to see and that which you are accustomed to contemplate in your own country. Here you will see the historical mines opened up shortly after the conquest, and the mining and metallurgical methods of the same epoch born of necessity (which, as you well know, is the mother of invention), in order to administer to the aggressive energy of our indomitable conquerors. Side by side with those glorious relics of past ages you will, in your visits to our mining localities, observe all the appliances with which modern science and art have prodigally enriched the mining industry, both for the exploitation of mineral deposits and the reduction of the ore, all of which appliances are, of course, entirely familiar to you.

"Seeing that I have referred to past times, it may not be surperfluous to recall one or two dates in the history of mining in Mexico, not boastfully, but in proof of the claim freely accorded to us of being the pioneer miners of the New World. I desire to refer to the first coinage of money here in the year 1537, the discovery of the system of amalgamation by Bartolome de Medina, in 1557, at Pachuca, and the opening of the School of Mines on January 1, 1792.

"In a country like Mexico, which possesses almost all known kinds of minerals, and among whose industries mining occupies in every sense the foremost rank, men who devote their thoughts and labors to the subject cannot but rejoice at being visited by persons so thoroughly versed as yourselves in all the branches of knowledge connected with the rational exploitation of metalliferous formations, ranging from the fundamental data of geology to the metallurgy of the industrial product, and from mineralogical prospecting to the installation of huge and complicated machinery destined to overcome natural obstacles.

"In proof of my assertion, I would point to the presence at this inaugural session of the distinguished citizen who administers the department which has charge of the mining interests of the country, and of the esteemed Director and President, as well as the members, of the three corporations on whose behalf I am addressing you, and which, by reason of their object, are intimately connected

with the scientific studies of mining in its varied aspects. Another proof of the interest felt in your work is the fact that the Supreme Government, through the Department of Justice and Public Instruction, has placed at your disposal for your meetings this, the auditorium of the old School of Mines.

"In connection with the conquests which mining has achieved in overcoming the forces of nature, either by deviating their course or moderating their intensity, permit me to say a few words with regard to the social and moral consequences of these conquests.

"The phenomena of nature are greatly modified by the action of man upon the planet, and it is precisely that struggle (never absent from mining operations) against the natural medium (which, even under the most favorable circumstances, does not yield the richest fruits of which it is capable, save in response to man's efforts) that constitutes the essential basis of the progress of nations.

"It is clear that that struggle must be in inverse ratio to the facilities which the soil and climate offer to mining operations and to their adaptation to man's wants, and that, therefore, there are countries where greater energy is needed than in others which are less unpropitious, as undoubtedly, in comparison with Mexico, are not a few of the countries of Europe and America. But if this circumstance explains a certain backwardness in the development of the less favored country, and to a certain degree lessens its responsibilities, seeing that it has had to contend with greater difficulties, it obliges it, on the other hand, morally speaking, to more constant and sustained efforts, with a view to overcoming its natural obstacles. Thus, the first and most important social question for each nation is, how to modify the physical medium in which it lives; and it must devote to that task, which is the foundation of all national development, the greater part of its strength and attention This is how the nations that have been most conspicuous in history have acted; so much so that many of them, occupying regions possessing few natural advantages, owe their position simply to the efforts of their people.

"The United States has had as natural allies in its successful development the fertility of its territory, its great rivers, the abundant supply of subterranean water in many regions and the mineral wealth of its soil; all of which things have contributed so largely to its industrial expansion. Another powerful factor in its favor is the immense extent of its coasts, offering unrivaled opportunities for the development of commercial navigation.

"Mexico is not so favorably situated, except with respect to its mineral wealth; for, although it has a great extent of coast, its shore line is not indented in such manner as to facilitate commerce and navigation. Thus it is that natural conditions have from the earliest times marked out the fundamental laws which, under penalty of great evils, each nation must obey in the process of its organization and development.

"And seeing that the similarity of the sub-soils of our respective countries and their proximity have given rise to a reciprocal interest in learning the condition of one another's mining industry, we consider it to be a duty on our part to throw open to you our museums, our mines and our reduction works, in order that you may inspect our mineral collections, our systems of mining, our metallurgical processes; for the interchange of ideas incidental to this class of reunions is not the least of their advantages.

"Our ancestors were accustomed to inaugurate every important enterprise, every momentous occasion, every useful institution, with the ceremonies of religion. Their fervent piety considered nothing to be noble, great nor sublime unless undertaken under the auspices of the Divine favor. Nowadays, we place

ourselves under the ægis of science; and those of us who march under its colors, with or without theological creed or political affiliations, invoke, above all things, when we meet to discuss and promote the welfare of mankind, the spirit of international co-operation which reunions of this kind tend to propagate, gathering as they do together, from different countries, men devoted to the cultivation of science—that treasure-house enriched by the patient accumulations of savants during the course of the centuries, and fortified by the indestructible hope of the ultimate brotherhood of man.

"We confidently hope that the fraternization of men of science in the United States and Mexico may ever grow closer, and we look for even pleasanter days in the future than those which we are about to enjoy on the occasion of your first collective visit. What *rôle* does the future reserve for our countries, and what will be, for us, the complexion of the ages to come? The course of history does not warrant prophecies, but a careful study of past ages frequently affords an insight into future probabilities; and when, in all ages, throughout every crisis, in every medium, we observe that the language in which men have most universally reached a common understanding is that of science, we may fairly conclude that the apostleship of fraternity in future ages is reserved for the men who faithfully, earnestly and enthusiastically devote their lives to the study of natural phenomena.

"We receive you, therefore, as professional brethren, and as intellectual sons of the same century. Welcome, therefore, to you members of the American Institute of Mining Engineers; and during your stay in our midst we hope not only that our scenery may delight you and our welcome gratify you, but that it may also be attended with intellectual results; for thus, upon returning to your home, you will carry with you grateful memories of your excursion to Mexico, and will be missionaries to tell of the cordial welcome here extended to men of science, particularly to those who are living examples of the motto on which every intellectual worker ought to pride himself: 'For Science, Fatherland and Humanity.'"

In response to this address, President E. E. Olcott made, in Spanish, the reply, of which the following is a translation:

"*Honorable Ministers of the Government, Members of the Academy of Sciences, of the Association of Engineers and Architects, and the Faculty of the National School of Engineers, and Other Distinguished Citizens of the Republic of Mexico.*

"*Gentlemen:* It is inspiring that this first meeting of the American Institute of Mining Engineers in Spanish America should be convened in the Mexican National School of Engineering, formerly the School of Mines.

"We, on our side of the Rio Grande, have something to be proud of in the magnitude of our operations and in the rapid advance which we have made not only in mining engineering, but along all lines. It is wholesome that we should assemble here before this brilliant audience, and should turn our thoughts backward and consider what we owe to the Latin races for our start. Was it not your Spanish ancestors who discovered the shores of the western hemisphere, and was not their quest for gold one of the great moving causes which lured them on? Our institutions, our great mining enterprises, dtae back but a few decades, while you can point out operations that have been moving along steadily for hundreds of years.

"When we discovered the Comstock Lode and our other western mines of early

date, where did we get our first miners, except from this country, where we are now so royally entertained? And when it came to treating our ores, on whom did we call for knowledge but on the Mexicans, who taught us the patio process, which we modified into the Washoe pan—merely your *arrastre* made of iron. Since then we have learned to love the term 'Pan;' and we prefix it to all our Congresses and all our Expositions! In early days we used it with reference only to the grinding and amalgamation of our silver-ores; but now the magic syllable is making of the peoples of all the western hemisphere a people of one interest in developing the immense riches with which nature has blessed us.

"Where did we get much of our nomenclature, if not from the beautiful Spanish language? Have we not received our *bonanzas* from you? Are there not more, hidden in your mighty mountains, which all of us wish to see developed in the best, most economical and most profitable manner?

"We did not, unfortunately, found our mining law on yours; if we had done so, the vexatious perplexities of the 'apex-question' would have been avoided, and the rational, understandable, rectangular claims would have been adopted.

"With a history in mining which surpasses all, with a present of tremendous importance, and with a future of brightest promise, Mexico is *par excellence* the Mecca for a congress of mining pilgrims.

"This magnificent edifice was erected for the accommodation of mining students before our people had awakened to the idea of our own possessions of mineral wealth. It behooves us Americans, then, to put away arrogance, as we enter your portals; to tread lightly the sacred halls; to look in reverence on your institutions, and to learn well the lessons which you can still teach us, of systematic perseverance. We are energetic, and wish to rush through our work in minutes; but we have much to learn from those who display the beautiful grace of patience.

"This meeting stands historically for several things. It marks the beginning of the thirtieth year of our Institute; it marks the opening of the momentous twentieth century; it marks the heartier co-operation of the different nations on this side of the Atlantic.

"If your progress and ours has been so great in the past thirty years, what may be expected in the first thirty years of this new century? 'Strength begets strength.' 'Well begun, half done.' You have advanced prodigiously of late. National and commercial ratings are such that the founding of enterprises of all sorts is easier and the interest charge not so serious as in former times. The multiplication of quicker methods of communication has not only developed your resources, but has also put the menace of rebellion further away.

"Our tariff legislation put a high duty on lead-ores, and attracted capital to establish immense smelting-works, which have gotten you a market close at hand for your ores. Compare your adobe furnaces, eight feet high, with the present '*hornos altos*.' And last, but not least, the maintenance of the highest national credit, under the guiding hand of the splendid statesman who holds the helm of the government—and the honorable payment of your public debt.

"It marks you a people that must be reckoned with. Mexico, like the United States, is suffering from an embarrassment of riches. No other nations on earth have to bother their heads as to what disposition to make of their surplus.

"The grand engineering schemes undertaken in Mexico in the last few years have involved the placing of millions of money in public betterments,—nearly $40,000,000 for harbors, $18,000,000 for canals.

"We want to learn, while here, why it is that in this happy land strikes are

unknown. It must be that sweet contentment blesses the hearthstone, and a man is free to go to his work as his needs and inclinations direct. May the blessings of this peace rest long upon you.

"There has been a notable increase of imports into Mexico from the United States, as against a large decrease of those from England and the comparatively small increase of imports from France, Germany and Spain. The same is true in regard to exports. There has been a phenomenal increase in the past two decades of metals and goods shipped to the United States, as against the bare maintenance, or a decrease, of the amount sent to Europe. We should not flatter ourselves in regard to this. Shame on us if it were not so, with our juxtaposition and our railroads and steamship facilities! But these conditions emphasize the necessity for more brotherly love between us, more helpfulness, less spirit of purely hostile competition, and more of mutual co-operation.

"Mexico now ranks third among the corn-raising countries of the world. Exports of agricultural products have more than doubled in the last eight years. The wonderful variety and quantities of what might be termed precious woods are a great source of national wealth, as is also the production of henequen, the annual sales of which have reached $33,000,000.

"Mexico has been, and is to be, congratulated and highly complimented for the large part she has taken in that marvel of beauty, that climax of up-to-date successes, the Pan-American Exposition at Buffalo. The spirit of the Pan-American idea, the spirit of hope engendered by that 'Rainbow City,' was never so strong as now. Let us all make generous endeavor that it may be lived up to in spirit and in truth. One of the greatest bonds for the security, the welfare and the advancement of Pan-America is an interoceanic canal. It has been talked of so long that the language of the early promoters has become a quaint tongue. Let us hope and assist as we may that under our newer condition action of some sort may begin. May the scream of the bald eagle of the North call forth an echoing hello from his brothers of the South—not ever, we pray, in defiance, but in inspiring rivalry and neighborly co-operation.

"Whatever measure of success has come to us of the States, aside from our natural advantages, we almost with one accord attribute to our belief in God, in the truth, and in our common schools, which teach us to find, to measure and to know the truth. So here we find a nation so compactly situated and so all-sufficient in its resources that for hundreds of years she has lived largely for herself and to herself. She has been so hemmed in by unpropitious coast lines, mountainous borders and vast distances that international exchanges were difficult. Return cargoes for ships were hard to secure, as her chief products, although of great value, were of small bulk; and so, until the advent of the great advance-agent of progress, the railroad, was begun over the length and breadth of the land, the vast wealth of many of her richest States lay dormant. Great men, great hearts and a great nation, not very many years ago, seemed to demand this newer life; and all things seem to have worked together for the common advance, until now the call of progress is answered day by day, more and more, from every part of the united and splendid nation. Here, too, we find a devout nation, and here we see springing up on all sides the common schools, which, like ours, tend to broaden and make more tolerant the opinions and religious beliefs of the people."

The session was concluded with a graceful address by Engineer Don Ezequiel Ordoñez, sub-Director of the Geological Institute of Mexico.

The proceedings were interspersed with musical selections, executed by the admirable orchestra of the National Conservatory of Music.

The second session was held in the same place on Monday morning, November 11th. Abstracts of the following papers, prepared and presented by direction of the Minister of *Fomento*, were read in Spanish by Engineer Don Ezequiel Ordoñez:

Historical Sketch of Mining Legislation in Mexico, by Eduardo Martinez Baca.

The Geographical and Geological Distribution of the Mines of the Republic of Mexico, by José G. Aguilera.

The following papers were presented in printed form:

The Mexican Railroad System, by Victor M. Braschi, City of Mexico.

The Mexican National School of Engineers, by Ezequiel Ordoñez, City of Mexico.

The Valley of Mexico, and the Federal District, by Ezequiel Ordoñez, City of Mexico.

The third session was held in the same place, on Tuesday, November 12th. Prof. Ordoñez read an English abstract of the following paper:

Mexican Railroads and the Mining Industry, by Luis Salazar.

The following paper was presented in oral summary by the author:

The Mining and Treatment of Low-Grade Copper Ores at Los Pilares, Nacosari, with Special Reference to the Use of Gas-Engines in Mining, by James Douglas, New York City.

The following papers were read by title, for subsequent publication, distribution and discussion:*

Note on Hydraulic Mining in Low-Grade Gravel, by William H. Radford, San Francisco, Cal. (P.)

The Sierra Mojada, Coahuila, Mexico, and its Ore-Deposits, by James W. Malcolmson, Chihuahua, Mexico. (P.)

* The papers marked "(P)" in this list were presented in print.

The Treatment of Clay-Slimes by the Cyanide Process and Agitation, by E. A. H. Tays and F. A. Schiertz, San Josê de Gracia, Sinaloa, Mexico. (P.)

Remarks upon Surveying Instruments with Special Reference to the paper of Mr. Dunbar D. Scott on the Evolution of Mine-Surveying Instruments, and its Discussions, by H. D. Hoskold, Buenos Aires, Argentine Republic.

The Tri-Axial Diagram with Rectangular Co-Ordinates, by H. E. Ashley, West Wareham, Mass.

Notes on the Pigholugan and Pigtao Gold-Regions, Island of Mandanao, Philippine Islands, by J. Clayton Nichols, Grand Junction, Colo. (P.)

Notes on a Section Across the Sierra Madre Occidental, of Chihuahua and Sinaloa, Mexico, by W. H. Weed, Washington, D. C.

The District of Hidalgo de Parral in 1820, by Norberte Domingues, Parral, Mex.

Notes on a Few Mines in the States of Chihuahua and Sinaloa, Mexico, by W. H. Weed, Washington, D. C.

Influence of Country-rock on Mineral Veins, by W. H. Weed, Washington, D. C.

The Alloys of Lead and Tellurium, by Henry Fay and C. B. Gillson, Boston, Mass. (P.)

The Alloys of Antimony and Tellurium, by Henry Fay and H. E. Ashley, Boston, Mass. (P.)

A Crystalline Sulphide in Pig-Iron, by Andrew A. Blair, Philadelphia, Pa., and Porter W. Shimer, Easton, Pa. (P.)

The Operation of the "Hole-Contract" System in the Center Star and War Eagle Mines, Rossland, B. C., by Carl R. Davis, Rossland, B. C. (P.)

Notes on the Mines and Minerals of Guanajuato, Mexico, by William P. Blake, Tucson, Arizona.

An Electric-Resistance Magnesia Crucible-Furnace for Laboratory Use, by H. M. Howe, New York City. (P.)

The Klein Jig and the Klein Classifier, by Ferdinand H. Regel, St. Louis, Mo. (P.)

Recent Geological Phenomena in the "Telluride Quadrangle" of the U. S. Geological Survey in Colorado, with Special Reference to the Report of Messrs. Cross and Purington upon that Area, by H. C. Lay, Telluride, Colo. (P.)

The Detection and Estimation of Small Quantities of Gold and Silver, by Luther Wagoner, Cathay, Cal.

Views of an Old Smelter in the State of Morelos, Mexico, by C. W. Pritchett, Jr., Denver, Colo. (P.)

Biographical Notice of R. P. Rothwell, by R. W. Raymond, New York City. (P.)

Diverse Origins and Diverse Times of Formation of the Lead-Zinc Deposits of the Mississippi Valley, by Charles R. Keyes, Des Moines, Iowa. (P.)

The Zinc- and Lead-Deposits of North Arkansas, by J. C. Branner, Stanford University, Cal. (P.)

The Pachuca Stamp-Battery and its Predecessors, by M. P. Boss, Mexico City, Mexico.

The Electrical Burner for Blast-Furnaces, by F. L. Grammer, Pueblo, Colo. (P.)

Notes on an Improved Form of Mining and Civil Engineers' Transit Theodolite, by H. D. Hoskold, Buenos Aires, Argentine Republic.

Study of Amalgamation Methods, Especially the Patio Process, with the Object of Avoiding the Loss of Mercury, by Miguel Bustamente, Jr., Mexico City.

Manganese Deposits of the Province of Santiago de Cuba: Their Origin, Formation and Commercial Value, by Eduardo J. Chibas, Guantanamo, Cuba.

An Adobe Reverberatory Furnace, by John Gross, Sombrerete, Zacatecas, Mexico.

A Synopsis of the Mining Laws of Mexico, by Richard E. Chism, Mexico City, Mexico.

A Glossary of Spanish-American Mining and Metallurgical Terms, by A. S. Dwight, San Luis Potosi, Mexico.

Some Experiments with Bromo-Cyanogen on Southern Gold-Ores, by S. H. Brockunier, Wheeling, West Va.

Studies in Mechanical Feeding of Silver-Lead Blast-Furnaces, by A. S. Dwight, San Luis Potosi, Mexico.

The Cyanide-Assay for Copper, by Harry Huntington Miller, Somerville, N. J.

Gems and Precious Stones of Mexico, by George F. Kunz, New York City.

Biographical Notice of Joseph Le Conte, by S. B. Christy, Berkeley, Cal.

The Value of Ores in Mexico, by N. H. Emmons 2d, Parral, Chihuahua, Mexico.

The Treatment of Tailings by the Cyanide Process at Athabasca Mine, near Nelson, British Columbia, by E. Nelson Fell, Nelson, B. C.

Notes on the Structure of Ore-Bearing Veins in Mexico, by Edward Halse, Medellin, Colombia, South America.

The Mineral Zone of Santa Maria del Rio, San Luis Potosí, by J. P. Manzano, San Luis Potosí, Mexico.

Geographic and Geologic Features of Mexico, by Robert T. Hill, Washington, D. C.

The Supposed Change from Combined to Graphic Carbon in Cast-Iron at 1000° C., by Edwin Bukofzer, Chattanooga, Tenn.

Preliminary Sanitary Examination of the Waters of Mexico, by Ellen H. Richards, Boston, Mass.

Litharge Process of Assaying Copper-Bearing Ores and Products and Method of Calculating Charges, by Walter G. Perkins, Grand Forks, B. C.

The Bar of Soto La Mariana; Its Present State and Works Necessary for its Improvement, by Alexandro Prieto.

Biographical Notice of James F. Lewis, by R. W. Raymond, New York City.

Drainage Works of the Valley of Mexico, by Luis Espinosa, Mexico City, Mexico.

The Steel Plant at Monterey, Mexico, by William White, Jr., Pittsburg, Pa.

Discussion of Howe on "The Constitution of Cast-Iron, with Remarks on Current Opinions Concerning It," by J. E. Stead, R. Moldenke, T. F. Witherbee and the author. (P.)

Discussion of Sargent on "A Study of the Effect of Heat-Treatment on Crucible Steel Containing One per cent. of Carbon," by H. D. Hibbard.

Continued Discussion of Van Hise on "Some Principles Controlling the Deposition of Ores," by C. R. Van Hise. (P.)

Discussion of Lucas on "The Great Oil Well near Beaumont, Texas," by E. T. Dumble.

Continued Discussion of Scott on "The Evolution of Mine-Surveying Instruments," by D. D. Scott and E. A. H. Tays. (P.)

Discussion of Drake on the Coal-Fields of Northeastern China," by F. Lynwood Garrison.

Discussion of Hedburg on "The Missouri and Arkansas Zinc-Mines at the Close of 1900," by F. Lynwood Garrison, J. C. Branner, H. W. Nichols.

Discussion of Hedburg on "The Missouri and Arkansas Zinc-Mines at the Close of 1900," by Eric Hedburg and W. A. Fleming Jones.

Discussion of Vogt on "Problems in the Geology of Ore-Deposits," by W. H. Weed.

Discussion of Davis on "The Operation of the 'Hole-Contract' System in the Center Star and War Eagle Mines, Rossland, B. C.," by F. H. Probert.

Discussion of Malcolmson on "The Sierra Mojada, Coahuila, Mexico," by S. F. Emmons.

On behalf of the Council, President Olcott proposed for immediate election to membership Sr. Don Manuel M. Contreras, mathematician and engineer, formerly Mayor of the City of Mexico, now a Senator of the Republic, and long connected with the School of Mines. The unanimous election of the candidate was emphasized by a rising vote, and acknowledged by him in a felicitous speech.*

After the adoption of a resolution instructing the officers of the Institute to express to the Government, the scientific and professional institutions, and the individual citizens of Mexico, and to the Local Committees throughout the Republic, a cordial acknowledgment of the courtesies extended to the Institute, the session was adjourned.

The fourth session was held at Pachuca, on Friday evening, Nov. 15. The following paper was read by the author:

* According to the Rules, the election to membership of candidates recommended by the Council may take place either at a meeting of the Institute or by postal ballot. The latter method has been almost exclusively followed in recent years, as saving time at the sessions of the Institute, and also furnishing better opportunity for deliberate action on the part of both Councils and members. In adopting this amendment, however, the Institute wisely left to the discretion of the Council a choice between the two methods, thus permitting, in exceptional cases, like the one here recorded, the immediate recognition of distinguished and unquestionable merit.

The Mining District of Pachuca, by Ezequiel Ordoñez, Mexico City.

And the following paper was read, in the absence of the author, by Stephen Waters, of Pachuca:

The Patio Process, by Manuel Valerio Ortego.

The fifth and concluding session was held Thursday afternoon, November 26, at Monterey, when the following papers were presented:

The Coal-Fields of Las Esperanzas, Coahuila, Mexico, by Edwin Ludlow, Baroteran, Coahuila, Mex.

The Iron Mountain of Durango and the Plant of the Mexican National Iron and Steel Company, by T. F. Witherbee, Durango, Mex.

Statistics of the Mining and Metallurgical Industry of the State of Nuevo Leon, Mexico, for the year 1900.

With the adjournment of this session, the formal proceedings of the Mexican meeting were ended.

Having been personally prevented by domestic bereavement from taking part in this meeting, the Secretary desires to acknowledge the inestimable service rendered by Mr. Theodore Dwight, Assistant Treasurer of the Institute, who, in addition to the onerous labor and responsibility of the organization and management of the Institute excursion-party, assumed, at a day's notice, the duties of Acting Secretary for the sessions and proceedings of the meetings.

Excursions and Entertainments.

These collateral features of the meeting are described and illustrated on page cxxxix of this volume.

Members and Associates Elected.

In addition to Sr. Don Manuel M. Contreras, elected at the third session, above reported, the following persons have been elected members or associates by postal ballots of March, June, August, October and December, 1901.

Members.

George I. Adams,	Washington, D. C.
Henry Adams,	Puerto Principe, Cuba.
Ponciano Aguilar,	Guanajuato, Mexico.
Andres Aldasro,	Mexico City, Mexico.
George E. Alexander,	Denver, Colo.
John W. Anderson,	Thacker, W. Va.
Edward Andrews,	Montreal, Canada.
Nels Oloff Bagge,	New York City.
Edward T. Bailey,	Carlisle, England.
Joseph T. Bailey,	New York City.
W. J. Barnett,	London, England.
Montagu T. Barney,	Auckland, New Zealand.
George Davis Barron,	Pueblo, Mexico.
William T. Batchelor,	Gormanston, Tasmania.
Christopher S. Batterman,	Butte, Mont.
Addison H. Beale,	Vandergrift, Pa.
Theodore Becker,	Telluride, Colo.
Sanford D. Belden,	Pittsburg, Pa.
Anson G. Betts,	Lansingburgh, N. Y.
David E. Bigelow,	San Diego, Cal.
Wilhelm Borchers,	Aachen, Germany.
G. S. Borden,	Huntington, Arkansas.
Frank K. Borrow,	Telluride, Colo.
Martin P. Boss,	Mexico City, Mexico.
Josiah Bowden,	Elkhorn, Mont.
Joseph H. Bowling,	Ozone, Tenn.
Augustus W. Boyd,	Spokane, Wash.
Thornton M. Boyd,	Beaconsfield, Tasmania.
John C. Brennon,	Torres, Sonora, Mexico.
Alfred J. Brett,	London, England.
Samuel D. Bridge,	Monterey, Mexico.
Roswell E. Briggs,	Mexico City, Mexico.
Arthur C. Brinker,	Ward, Colorado.
Wallace Broad,	London, England.
James Brophy,	Eagle, W. Va.
Donald C. Brown,	San Luis Potosi, Mexico.
Walter J. Browning,	Las Cruces, N. M.
Ernest R. Buckley,	Rolla, Mo.
Lester R. Budrow,	Santa Barbara, Chihuahua, Mexico.
Edwin Bukofzer,	Chattanooga, Tenn.
Walter E. Burlingame,	Denver, Colo.
José Calero,	Las Cajas, Pachuca, Mexico.
Carlos F. Z. Caracristi,	New York City.
Henry M. Carter,	Monterey, Mexico.
Adolfo Martinez Ceballos,	San Luis Potosi, Mexico.
Louis Chevrillon,	Mexico City, Mexico.
Luis Floro Chibas,	Santiago de Cuba.
Peter Christianson,	Minneapolis, Minn.
George C. Clark,	Bisbee, Arizona.
W. B. Clarke,	Schenectady, N. Y.

Newton Cleaveland,	Oroville, Cal.
J. Morgan Clement,	Madison, Wis.
J. Harold Clouston,	Derby, Tasmania.
Hervic N. G. Cobbe,	Coolgardie, Western Australia.
Louis Cohen,	Zacatecas, Mexico.
George L. Collord,	Sharpsville, Pa.
Owen J. Conley,	New York City.
Henry M. A. Cooke,	Oorgaum, Mysore, India.
Lewis H. Cooke,	London, England.
William A. Cornelius,	McKeesport, Pa.
Russell T. Cornell,	New York City.
J. P. Cosgro,	Rossland, British Columbia.
Charles H. Cutting,	Troy, Arizona.
Charles S. Davis,	Mexico City, Mexico.
Charles W. Davis,	Allegheny, Pa.
Frank S. Davis,	Diamondville, Wyoming.
Herman Davis,	Dayton, Nevada.
Stewart A. Davis,	Vandergrift, Pa.
William Dempster,	Pollokshields, Scotland.
Ralph Dillon,	New York City.
Charles M. Donohoe,	Redding, Cal.
Theodore Douglas,	Topia, Durango, Mexico.
G. D. Doveton,	Ouray, Colo.
Maurice Downey,	Troy, Mont.
Norman M. Dudgeon,	London, England.
Arthur R. Earnshaw,	Steelton, Pa.
Benjamin P. Ekberg,	London, England.
Norris English,	Oakland, Cal.
Luis Espinosa,	Mexico City, Mexico.
Edward P. Fleming,	Troy, Arizona.
William H. Fluker,	Tatham, Ga.
Emil A. Franke,	Chicago, Ill.
William H. Freeland,	Isabella, Tenn.
Stanton S. Freeman,	Parryville, Pa.
Dwight Furness,	Guanajuato, Mexico.
Telesforo Garcia, Jr.,	Mexico City, Mexico.
Russell D. George,	Iowa City, Iowa.
Thomas W. Gibson,	Toronto, Ontario, Canada.
Clarence I. Glassbrook,	Aspen, Colo.
Karl Fr. Göransson,	Sandviken, Sweden.
James B. Gore,	Lumpkin, Cal.
B. B. Gottsberger,	Copper Hill, Tenn.
Charles N. Gould,	Norman, Oklahoma.
G. H. Grant,	Victoria, British Columbia.
Ulysses S. Grant,	Evanston, Ill.
MacDowell Graves,	Mexico City, Mexico.
John C. Gwillim,	Nelson, British Columbia.
Warren A. Haggott,	Idaho Springs, Colo.
George Hall,	El Oro, Mexico.
Newman G. Hall,	Aspen, Colo.
Wendell P. Hammon,	Oroville, Cal.
Herbert R. Hanley,	Winthrop, Cal.

John A. Hanley, Jr.,	Aguas Calientes, Mexico.
Harry C. Harrington,	Newark, N. J.
Alfred W. Harrison,	Victor, Colo.
Roger H. Hatchett,	Argentine, Kansas.
Alexander M. Hay,	Rat Portage, Ontario, Canada.
Henry Hay,	Johannesburg, Transvaal, So. Africa.
John H. Heal,	Alamo, British Columbia, Canada.
Arthur E. Healey,	Sunshine, Colo.
James Hebbard,	Broken Hill, New South Wales.
Otto F. Heckelmann,	Mexico City, Mexico.
James D. Helm,	Santa Barbara, Chihuahua, Mexico.
Everard Heneage,	Johannesburg, So. Africa.
Marcus F. Hernandez,	Monterey, Mexico.
Lawrence C. Hodson,	Ames, Iowa.
Barry Hogarty,	New York City.
L. F. S. Holland,	Waverley, Nova Scotia.
John J. Hollister,	Gaviota, Cal.
Ozni P. Hood,	Houghton, Mich.
Gerald von Hopkins,	Salmo, British Columbia, Canada.
George W. Horner,	Mullan, Idaho.
James H. Howard,	Ameca, Jalisco, Mexico.
Joshua Hunt,	Monterey, Mexico.
John D. Irving,	Washington, D. C.
Webster T. James,	Chattanooga, Tenn.
T. G. Janney,	Centreville, Idaho.
Thomas Jenkins,	Medlin, N. C.
George N. Jeppson,	Worcester, Mass.
Richard M. Jessup,	New York City.
William C. Jirdinston,	Auburn, N. Y.
Alexander T. Johnson,	Aguas Calientes, Mexico.
Evan R. Jones,	Las Esperanzas, Coahuila, Mexico.
Walter A. F. Jones,	Mansfield, Mo.
William S. Jones,	Greensburg, Pa.
Arthur Judge,	Gadzema, Mashonaland, Rhodesia, So. Africa.
Burt Z. Kassm,	Gloversville, N. Y.
Robert L. Kayser,	Monterey, Mexico.
Peter J. Keam,	Ravensthorpe, Western Australia.
Nathaniel S. Keith,	New York City.
George C. Klug,	Boulder, Western Australia.
Isaac N. Knapp,	Chanute, Kansas.
William Knox,	Melbourne, Australia.
William Koehler,	Cleveland, Ohio.
George J. Krebs,	Somerset, Pa.
George A. Laird,	Matehuala, Mexico.
Mark Lamb,	Hedges, Cal.
Richard Lamb,	Highhill, Va.
John Langton,	New York City.
James C. E. Lawson,	London, England.
William H. Leffingwell,	Cripple Creek, Colo.
Oscar T. Lempriere,	Melbourne, Australia.
Prof. Lengemann,	Aachen, Germany.

William A. Lindsay,	Las Esperanzas, Coahuila, Mexico.
James Lindsey,	Portland, Oregon.
Archibald Little,	London, England.
Frank Longmaid,	Marysville, Mont.
Vernon F. S. Low,	Kilda, Queensland, Australia.
Lionel Ludlow,	Buluwayo, Rhodesia, So. Africa.
Ernest Du Bois Lukis,	Puebla, Mexico.
Ferdinand McCann,	Mexico City, Mexico.
George L. McCarty,	Torres, Sonora, Mexico.
Jackson C. McChrystal,	Eureka, Utah.
William P. McComas,	Beverley, Cal.
Lesley McCreath,	Harrisburg, Pa.
E. H. McCullough,	Philadelphia, Pa.
Alexander K. McDaniel,	Butte, Mont.
John A. McDonald,	Cape Town, So. Africa.
William T. McDonald,	Los Angeles, Cal.
John McGrath,	Tlalpujahua, Mexico.
John M. McGregor,	Slocan, British Columbia, Canada.
J. A. McKee.	Monterey, Mexico.
William A. MacLeod,	Queensland, Australia.
S. G. McNulty,	Thacker, W. Va.
R. W. Macfarlane,	Ymir, British Columbia, Canada.
William Magenau,	Fredericktown, Mo.
Frank A. Manley,	Rock Springs, Wyoming.
William S. Mann,	Miramar, Costa Rica, Central America.
William O. Manson,	Denver, Colo.
J. H. Marriner,	Kalgoorlie, Western Australia.
Chester W. Maxson,	Lordsburg, New Mexico.
John W. C. Maxwell,	San Francisco, Cal.
Albert E. May,	Caethe, Brazil, So. America.
Jesse J. May,	Idaho Springs, Colo.
W. H. Mealy,	Monterey, Mexico.
Alcides Medraro,	Ouro Preto, Minas Geraes, Brazil.
Herbert A. Megraw,	Guanajuato, Mexico.
Fritz Mella,	Rapid City, So. Dakota.
Edward P. Merrill,	Daiquiri, Santiago, Cuba.
Edwin H. Messiter,	San Luis Potosi, Mexico.
James W. Meyers,	Florence, Colo.
Loring R. Millen,	New York City.
Harry E. Miller,	San Francisco, Cal.
Eugene C. Mills,	Virginia, Minn.
Louis D. Mills,	Lead, So. Dakota.
John Moffatt,	Irvinebank, No. Queensland, Australia.
Fred. L. Morris,	San Jacinto, Cal.
Henry C. Morris,	Georgetown, Colo.
Edwin Morrison,	Philadelphia, Pa.
Horace Moses,	Santa Rita, New Mexico.
John W. Mould,	Cockle Creek, New South Wales.
Thomas King Muir,	Portland, Oregon.
Ernest W. Nardin,	Seoul, Korea.
William F. Nawatny,	Bowie, Texas.
Harvey B. Nichols,	Selby, Cal.

Hadson H. Nicholson, ...	Lincoln, Nebraska.
George R. Nicolaus, . . .	London, England.
Frank L. Norris, ...	Durango, Mexico.
Alexander Orr.	Sydney, Australia.
Clement H. Pallen, ...	Fort Steele, British Columbia.
Ernest E. Palmer, ...	Texada Island, British Columbia.
George A. Paterson, . . .	Oorgaum, Mysore, India.
H. Pauli, ...	Frankfort-on-Main, Germany.
Harold V. Pearce, ...	Argo, Colo.
Juan Pedrazzini, ...	Locarno, Switzerland.
Walter G. Perkins, ...	Grand Forks, British Columbia.
Oscar B. Perry, ...	Oroville, Cal.
Richard Peters, Jr., . . .	Chester, Pa.
Jos. L. Phillips, ...	Mexico City, Mexico.
Edwin H. Platt, ...	Denver, Colo.
Robert H. Postlethwaite, . .	San Francisco, Cal.
Robert W. Powell, ...	Thames, New Zealand.
Robert W. Pringle, ...	Edinburgh, Scotland.
John L. Pultz, ...	New York City.
Keith D. Quarrier, ...	Charleston, W. Va.
Edward Randolph, ...	Newark, N. J.
Fred R. Raven, ...	Nuttallburg, W. Va.
S. S. Raymond, ...	Bay Point, Cal.
Richard W. Reading, . . .	Selby, Cal.
Daniel W. Reckhart, . . .	El Paso, Texas.
Frederick L. Reynolds, . . .	Hermosillo, Sonora, Mexico.
Albert B. Richmond, . . .	Socorro, New Mexico.
Chester C. Robbins, . . .	Lawton, Oregon.
Percy A. Robbins, ...	Kimberley, So. Africa.
Cyrus S. Roberts, ...	Oakland, Cal.
Milnor Roberts, ...	Seattle, Wash.
Alfred von der Ropp, . . .	Oakland, Cal.
Carlton R. Rose, ...	Golden, Colo.
Lewis G. Rowand, ...	Newark, N. J.
S. W. Russell, ...	Deadwood, South Dakota.
William Russell, ...	Denver, Colo.
Thomas J. Ryder, ...	Mexico City, Mexico.
Reno H. Sales, ...	Butte, Mont.
Henry S. Sanderson, . . .	Idaho Springs, Colo.
James V. Scaife, ...	Pittsburg, Pa.
F. A. M. Schiechel, . . .	Frankfort-on-Main, Germany.
Robert Schorr, ...	Kennett, Cal.
Albert J. Sharpe, ...	Las Esperanzas, Mexico.
Clarence M. Schwerin, . . .	New York City.
Herbert P. Seale, ...	Queensland, Australia.
Harry L. Shrom, ...	Concord, N. C.
William J. Sims, ...	Mexico City, Mexico.
William L. Sims, ...	Catasauqua, Pa.
Arvid Sjögren, ...	Avesta, Sweden.
John H. Slavens, ...	Argentine, Kansas.
Charles E. Sloan, ...	Salt Lake City, Utah.
Edward P. Smith, ...	Tombstone, Arizona.

Frederick D. Smith, ...	Ely, Nevada.
Thorn Smith, ...	Isabella, Tenn.
George R. Snover, ...	San Juancito, Honduras, C. A.
George Spence, ...	Mexico City, Mexico.
Arthur C. Spencer, ...	Washington, D. C.
G. Stadelmann, ...	Mexico City, Mexico.
R. B. Stanford, ...	Columbia, Cal.
J. V. R. Stehman, ...	Birdsborn, Pa.
Alfred E. Stephen, ...	Sydney, New South Wales.
Henry Stern, ...	New York City.
Philip C. A. Stewart, . . .	London, England.
Gustavus H. Stoiber, . . .	Silverton, Colo.
Henry N. Stokes, ...	Washington, D. C.
Contantino de Tarnava, . . .	Monterey, Mexico.
Frank A. Taylor, ...	Jackson, Cal.
F. M. Taylor, ...	Victor, Colo.
Laurence M. Terry, . . .	New York City.
Bartlett L. Thane, ...	Sumdum, Alaska.
Chester A. Thomas, . . .	Jerome, Arizona.
William E. Thorne, . . .	Georgetown, Cal.
Sydney Thow, ...	Mount Read, Tasmania.
Hugh P. Tiemann, ...	New York City.
R. H. Toll, ...	Mancos, Colo.
George W. Tower, ...	Butte, Mont.
Arthur R. Townsend, . . .	Guayaquil, Ecuador, So. America
Herbert E. Tuttle, ...	Monterey, Mexico.
Arthur J. Underwood, . . .	Robinson, Utah.
W. E. Upham, ...	Matehuala, Mexico.
Charles F. Valentine, . . .	No. Queensland, Australia.
Charles E. van Barneveld, . .	Minneapolis, Minn.
Charles McK. Van Cleve, . .	San Luis Potosi, Mexico.
Frank L. Van Orden, . . .	Houghton, Mich.
F. E. Van Slyke, ...	Charleston, W. Va.
John Allen Veatch, . . .	Maxwell, Cal.
Maurice A. Viele, ...	Schenectady, N. Y.
C. F. von Petersdorff, . . .	New York City.
Elton W. Walker, ...	Detroit, Mich.
Frank S. Warmoth, . . .	Lawrence, La.
Stephen Waters, ...	Pachuca, Mexico.
Winfield S. Watson, . . .	Mexico City, Mexico.
W. H. Wesley, Jr., . . .	Queenstown, Tasmania.
Ernest H. Webb, ...	Brooklyn, N. Y.
Christopher M. Weld, . . .	Storey Place, Mass.
Charles H. White, ...	Cambridge, Mass.
Norman F. White, ...	Queensland, Australia.
Frank B. Williams, . . .	Marysville, Mont.
Alfred B. Willis, ...	Kingston Hill, Surrey, England.
Arthur B. Willmott, . . .	Sault Ste. Marie, Ontario, Canada.
Alexander N. Winchell, . . .	Butte, Mont.
Jerry M. Wines, ...	El Paso, Texas.
Frederick A. Wright, . . .	Monterey, Mexico.
John C. Young, ...	Baker City, Oregon.

Lewis E. Young, ...	Ames, Iowa.
Morrison B. Yung, ...	San Padro, New Mexico.
Adolfo Zambrano, ...	Monterey, Mexico.

Associates.

Charles E. W. Bateson, . . .	New York City.
S. A. B. Blandy, ...	Freiberg, Germany.
Fred. J. Boyd, ...	Sombrerete, Zacatecas, Mexico.
Henry C. Boynton, ...	Cambridge, Mass.
George A. Camphuis, . . .	London, England.
Lucien Eaton, ...	Cambridge, Mass.
Augustus H. Eustis, . . .	Readville, Mass.
Frederick A. Eustis, . . .	Cambridge, Mass.
J. M. Fitzgerald, ...	Catasauqua, Pa.
Thomas Gunn, ...	Launceston, Tasmania.
Edwin I. Harrington, . . .	Yonkers, N. Y.
Moritz Hochschild, ...	Mexico City, Mexico.
James M. Hyde, ...	Palo Alto, Cal.
W. J. Johnson, ...	New York City.
J. Gibson McIlvain, . . .	East Downingtown, Pa.
Ralph L. Montague, . . .	Oroville, Cal.
Edwin Morrison, ...	Philadelphia, Pa.
William M. Parkin, . . .	New Kensington, Pa.
William B. Scaife, ...	Pittsburg, Pa.
Bernard E. Schnatterbeck, . .	New York City.
Lindsay Tulloch, ...	Launceston, Tasmania.

Associates Made Members.

H. S. Bonestall, ...	Jackson, Cal.
H. F. Kendall, ...	Virginia, Minn.
John R. Powell, ...	Telluride, Colo.
Eugene C. Roberts, ...	Buffalo, N. Y.
John R. H. Robertson, . . .	Denver, Colo.
J. R. Stanton, ...	New York City.
W. J. Sutherland, ...	New York City.
W. Murdoch Wiley, . . .	Gold Hill, N. C.

Mexican Meeting Excursion

Excursions and Entertainments Connected with the Mexican Meeting, November, 1901.*

The convenience and pleasure of members and guests attending this meeting was served, while the expense of the journey was very greatly reduced, through the organization of a special excursion-party by Mr. Theodore Dwight, whose executive ability in this direction, already exhibited on more than one similar occasion, was never more severely tested, or (if the Secretary may trust the unanimous verdict of the travelers concerned) more conspicuously proved, than in this peculiarly difficult case.

The party occupied two special trains, one of which started from New York City, via the Pennsylvania Railroad, on November 1st, at 2.20 P.M. The second train followed the first out of Chicago at 10 P.M. on November 2d.

Train No. 1.—This train was composed of the Pullman sleepers "Wildwood" (4 drawing-rooms and 8 sections), "Horatio" (2 drawing-rooms and 7 compartment state-rooms), and "Petruchio" (2 drawing-rooms and 12 sections); the private car "Olympia" (chartered by President Olcott for his own use, one of the large state-rooms of which was kindly placed at the disposal of Mr. Dwight, as an office); and the observation-car "Pacific" (8 sections, bath-room, large parlor and recessed observation platform). To these were added two 60-ft. Pennsylvania Railroad (Adams' Express) baggage-cars. One of these, fitted up as a refrigerator- and storage-car after

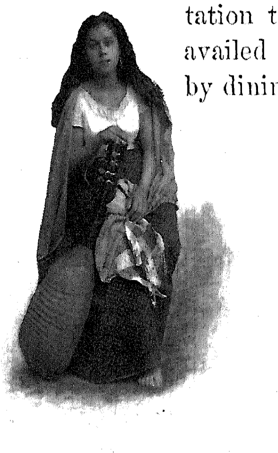
* A Supplement to the Official Proceedings of the Meeting.

designs by Mr. Dwight, carried out of New York over 40,000 lbs. of commissary supplies, in addition to which, over 10,000 lbs. were stored in the dining- and the other baggage-cars. These supplies included about 5000 lbs. of fresh meats, 1000 lbs. of ham, 200 lbs. of bacon, 4500 cans of fruits and vegetables, many barrels of fresh fruits and vegetables, 750 lbs. of fresh butter, 3100 qts. of "White Rock" water, in addition to other supplies required for such a trip in a foreign country, where American food-supplies are often difficult to obtain.

The second baggage-car was provided in one end with bunks to accommodate ten persons, partitioned off from that portion in which the trunks were stored. This was done to eliminate a very serious objection common to the usual tourists' trips, where the cooks and crew are permitted to sleep on the tables and floors of the dining-cars.

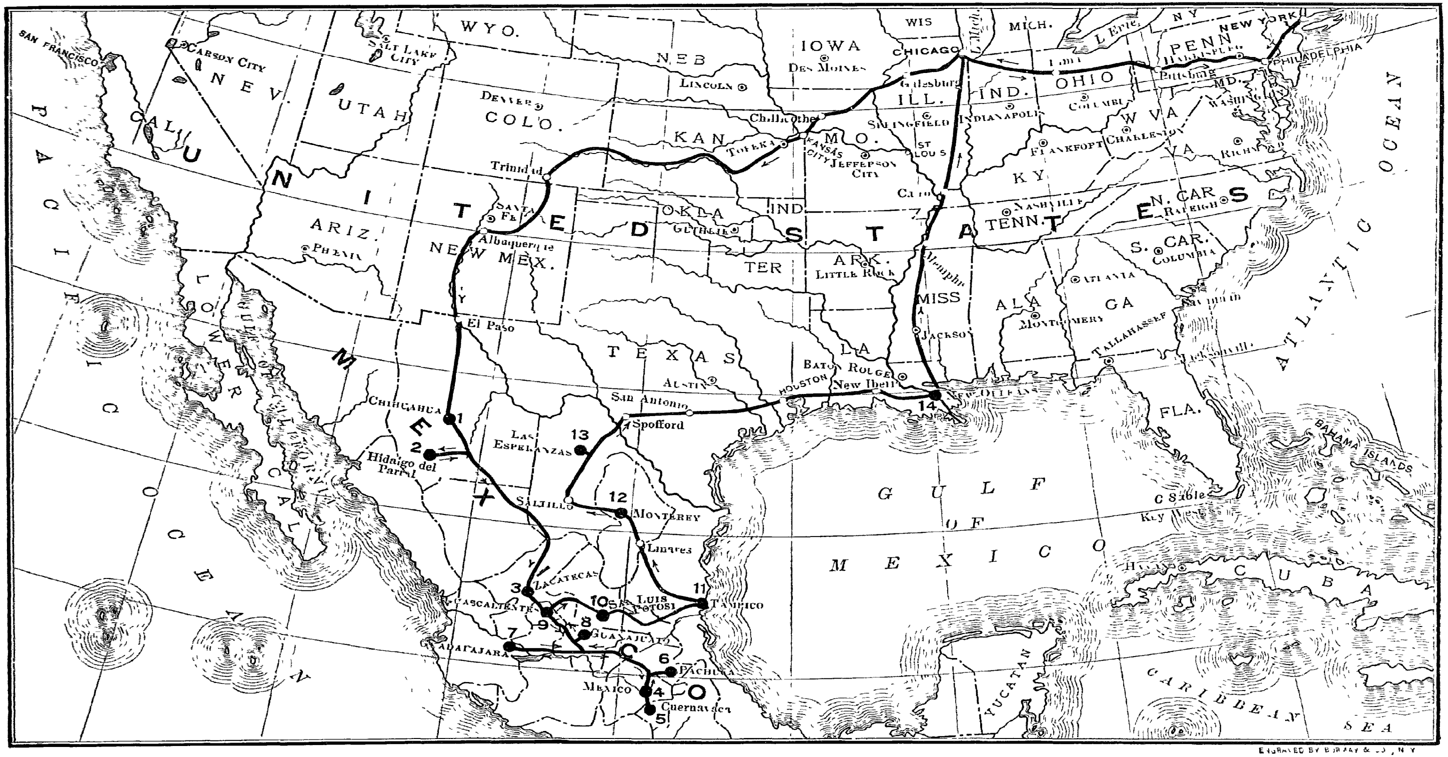
The train carried about 85 passengers and a crew of about 22 persons, including, in addition to the regular force of waiters, porters, cooks, etc., a baggage-man, barber, store-keeper and maids.

The journey to Chicago was made without incident. The trip had brought together many old friends, and in the 24 hours' run all others became well acquainted. Owing to the very great weight of the train, the "limited" schedule could not be maintained, and the arrival at Chicago was an hour behind time. The Engineers' Club of that city had extended an invitation to members and guests of which many availed themselves, during their 7 hours' stay, by dining at the Club.



While the party was absent from Train No. 1, it was taken to the Atchison, Topeka and Santa Fe station, and the baggage of those who were to be accommodated on the second train transferred to the baggage-cars of that train.

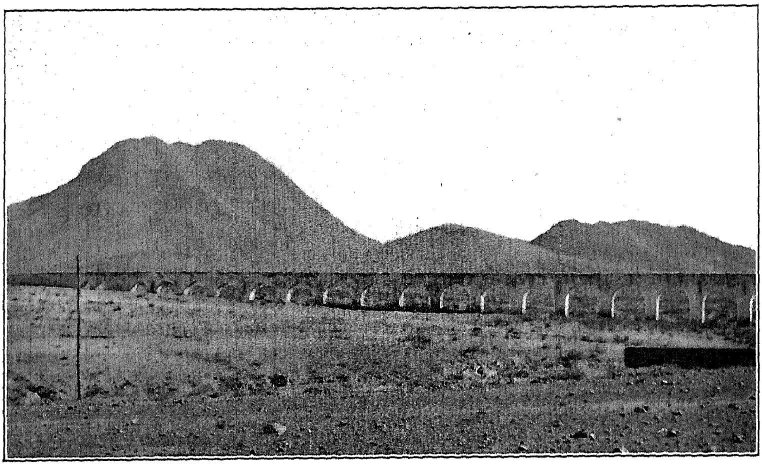
At 10 P.M. the first train left the station, followed shortly afterward by



Route of the Excursion to the Mexican Meeting, November, 1901.

the second. The intention had been to keep the two sections within a few minutes of each other; but owing to a defective gas-valve in one of the cars of the second section, considerable delay occurred at Kansas City. The "right of way" was thus lost; and the two trains did not come together again until their arrival at Raton, N. M.

Train No. 2.—This was composed of the compartment-cars "Bassanio" and "Philario;" the sleepers "Bernardo" and "Cloverdale" (each having 2 drawing-rooms and 12 sections); the private car "Chiricahua" of Dr. James Douglas (which joined the train at El Paso); the observation-car "Aladdin;" and two baggage-cars, one belonging to the Mexican Central



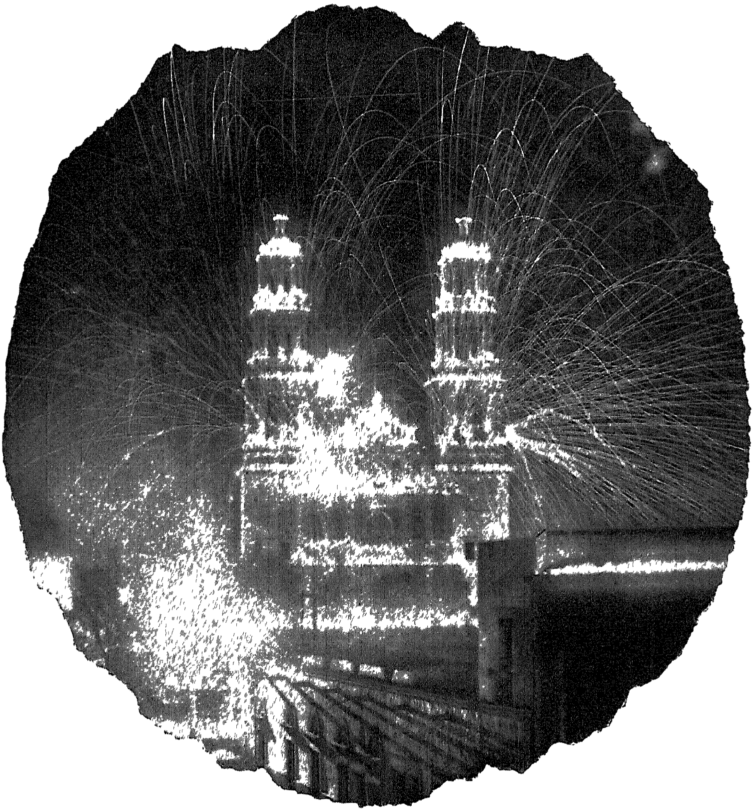
Aqueduct from Chihuahua.

railroad, and the other courteously furnished by the Chicago, Milwaukee and St. Paul Railroad Company.

As regarded the comfort and guidance of passengers, this train was under the charge of Mr. E. W. Parker, of New York City, who kindly volunteered his valuable assistance in this respect.

General Equipment and Operation.—No more striking proof of the excellence of American railway equipment and management could be desired than was given by this continuous excursion of nearly 8400 miles, made with trains of exceptional length and weight, over road-beds of variable excellence (and, sometimes, very bad), including extreme grades and sharp

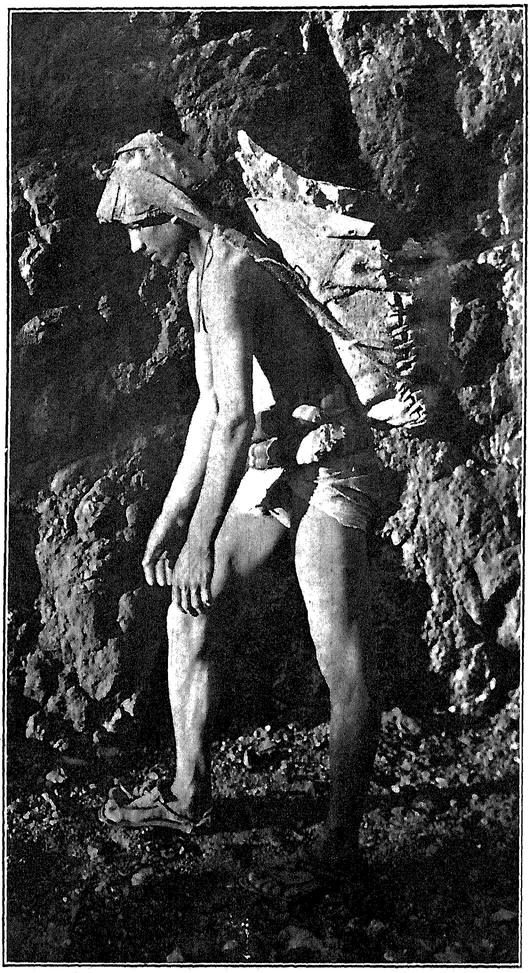
curves. It is not long since the sending of a single car on a journey of such length and character, without opportunity for shop-repairs, would have been deemed a hazardous experiment. And still more hazardous would have been the submission of seventeen cars to such a test. For it must be remembered that whereas, on a single line, under one control, and provided (as are our great transcontinental or trunk-lines) at frequent inter-



The Night Picture of the Illuminated Cathedral at Chihuahua.

vals, with repair-shops, depots of train-supplies or duplicate parts, and even stations where substitute cars could be obtained in an emergency, the result of a break-down in some detail of equipment might be only insignificant inconvenience or delay, such an accident, occurring on a new line, or in a foreign country, far from any available, immediate remedy, would be a much more serious matter. Apart from the difficulty or impossibility of adequate temporary repairs, necessitating the

abandonment of a car and the accommodation of its inmates through the over-crowding of the remaining cars, the simple delay occasioned by such an event, under such conditions, might entirely nullify the whole of the time-schedule, laboriously constructed, and accepted by the different railroad com-



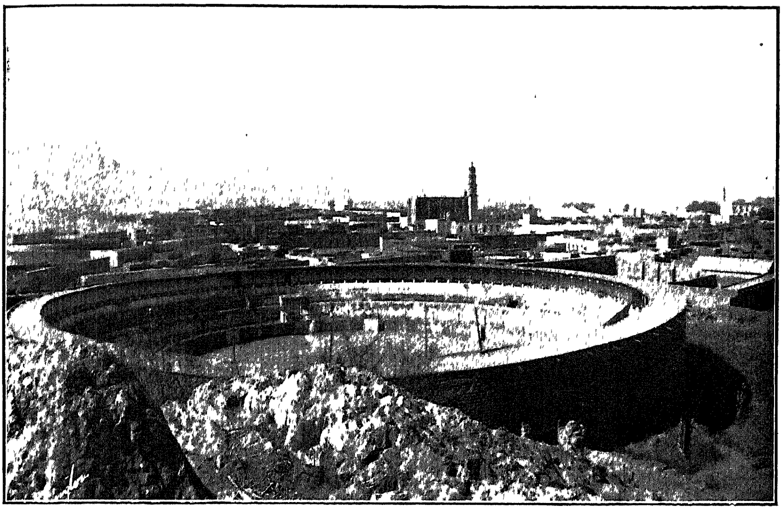
Indian Ore-Carrier at Parral.

panies concerned, so as not to interfere with their regular business and their obligations as mail-carriers.

In other words, after all possible precautions and pre-arrangements, the success of such an excursion absolutely depended, in the last analysis, upon the behavior of the railway equip-

ment furnished; and the mere circumstance that this equipment could be reasonably calculated upon to endure the test of a month's continuous and severe use speaks volumes either for the sanguine temperament of the organizers of such an undertaking or else for American railway construction and administration. The further circumstance that such an expectation was actually justified by the event proves the latter, rather than the former.

There were two trifling break-downs in the plumbing of the two trains, and there was a little trouble with the fittings of the private car "Chiricahua"; but this was all. In the whole



Bull-Ring, Parral.

8545 miles traveled, not one car developed even so much as a "hot box;" and at the end of the 30 days, with all their vicissitudes and varied exigencies, the double party was brought into Chicago on the day appointed, two hours ahead of its schedule-time!

This final triumph was due to the notable run of 923 miles from New Orleans to Chicago, over the lines of the Illinois Central system, upon which the rate already set by a "fast" schedule was so far exceeded as to gain the two hours mentioned. Over many parts of the line the speed of 70 miles per hour was made, without danger or discomfort to the party. Engineers will see at once that this performance shows not

merely the excellence of engines and rolling-stock, but also the perfection of the road-bed.

This remarkable record, besides illustrating the perfection of American railway practice, dictates a hearty acknowledgment of the zealous co-operation of the officials and employees of the various railroads traversed, and especially of those of the Pullman Company. According to the strict rules established for the excursion, no individual fees were paid en route to porters, waiters, etc., but every member of the party gladly subscribed to a purse of about $1800, which was distributed among them at the end of the journey.

The perfection of the commissariat is indicated by the fact that more than 15,000 meals were served on the two trains to the 165 passengers and 45 members of the crews, etc., and to many Mexican local members or Committees received and entertained upon the trains for brief periods. And the Secretary has neither received any report, nor heard any rumor, of a single instance of dissatisfaction with the management of this department.

Distance Traveled.—The following memorandum shows the distance traveled by this party from Nov. 1 to Dec. 1, 1901:

	Miles.
New York City to Philadelphia,	90
Philadelphia to Chicago,	822
Chicago to El Paso,	1630
El Paso to Chihuahua,	226
Chihuahua to Jiminez,	146
Jiminez to Parral and return,	110
Parral to Santa Barbara and Minas Nuevas,	34
Jiminez to Zacatecas,	416
Zacatecas to Mexico City,	439
Mexico City to Drainage Canal and return,	34
Mexico City to Cuernavaca and return,	150
Mexico City to Pachuca,	93
Pachuca to Tula,	44
Tula to Guadalajara,	331
Guadalajara to Guanajuato,	194
Guanajuato to Aguascalientes,	144
Aguascalientes to San Luis Potosi,	140
San Luis Potosi to Smelter and return,	6
San Luis Potosi to Cardenas,	117
Cardenas to Cafetal,	27
Cafetal to El Abra Falls,	53
El Abra Falls to Tampico (La Barra),	84
Tampico (La Barra) to Monterrey,	327

Monterrey to Zaragosa and return,	30
Monterrey to Baroteran,	195
Baroteran to Coal Mines and return,	20
Baroteran to Eagle Pass,	102
Eagle Pass to New Orleans,	740
New Orleans to Chicago,	923
Chicago to Philadelphia,	822
Philadelphia to New York City,	90
Total,	8579

List of the Excursion Party.—The following list contains the names of those who constituted the party:

W. P. Agnew,	New York.
H. B. Alexander,	Sandon, B. C.
R. M. de Arozarena,	Mexico City, Mexico.
Mr. Franklin Bache,	Alderson, I. T.
Mrs. Franklin Bache,	Alderson, I. T.
Mr. Hugh A. Bain,	New York, N. Y.
Mrs. Hugh A. Bain,	New York, N. Y.
Mrs. S. K. Barker,	Scranton, Pa.
Miss Barker,	Scranton, Pa.
Mr. E H. Benjamin,	San Francisco, Cal.
Mrs. E. H. Benjamin,	San Francisco, Cal.
L. S. Bigelow,	New York, N. Y.
Mr. C. E. Billin,	Chicago, Ill.
Mrs. C. E. Billin,	Chicago, Ill.
Frank S. Bond,	New York, N. Y.
Frank Borrow,	Telluride, Colo.
Miss Hally R. Bryan,	Washington, D. C.
Mr. F. J. Campbell,	Denver, Colo.
Mrs. F. J. Campbell,	Denver, Colo.
Dr. Thomas M. Chatard,	Washington, D. C.
Mrs. Thomas M. Chatard,	Washington, D. C.
Maurice Clark,	Mexico City, Mexico.
Mr. William Bullock Clark,	Baltimore, Md.
Mrs. William Bullock Clark,	Baltimore, Md.
W. B. Cogswell,	Syracuse, N. Y.
Mr. F. Collingwood,	New York, N. Y.
Mrs. F. Collingwood,	New York, N. Y.
Mr. A. L. Collins,	Telluride, Colo.
Mrs. A. L. Collins,	Telluride, Colo.
Mr. Edgar S. Cook,	Pottstown, Pa.
Mrs. Edgar S. Cook,	Pottstown, Pa.
Miss Eleanor Coxe,	Toledo, Ohio.
Mr. Samuel W. Croxton,	Cleveland, Ohio.
Mrs. Samuel W. Croxton,	Cleveland, Ohio.
Mr. William M. Cummings,	Mexico City, Mexico.
Mr. J. H. Devereux,	Aspen, Colo.
Mrs. J. H. Devereux,	Aspen, Colo.
Mr. W. B. Devereux,	New York, N. Y.
Mrs. W. B. Devereux,	New York, N. Y.
Mr. Samuel Dixon,	McDonald, W. Va.
Mrs. Samuel Dixon,	McDonald, W. Va.

Dr. James Douglas,	New York, N. Y.
Miss Douglas,	New York, N. Y.
Mrs. J. S. Douglas,	Morenci, Arizona.
Master Douglas,	Morenci, Arizona.
Mr. Arthur S. Dwight,	New York, N. Y.
Mrs. Arthur S. Dwight,	New York, N. Y.
Theodore Dwight,	New York, N. Y.
Clarence Edsall,	Colorado Springs, Colo.
Prof. S. F. Emmons,	Washington, D. C.
W. E. C. Eustis,	Boston, Mass.
Frederick A. Eustis,	Boston, Mass.
Augustus H. Eustis,	Boston, Mass.
Thomas M. Eynon,	Philadelphia, Pa.
James Eynon,	Philadelphia, Pa.
Mr. B. F. Fackenthal, Jr.,	Easton, Pa.
Mrs. B. F. Fackenthal, Jr.,	Easton, Pa.
Dr. William J. Ford,	Washington, Conn.
Fritz J. Frank,	Chicago, Ill.
Walter C. Gayhart,	Austin, Nev.
C. W. Haines,	Philadelphia, Pa.
Miss Frances B. Hawley,	New York, N. Y.
M. Hochschild,	Mexico City, Mexico.
Mr. L. Holbrook,	Mexico City, Mexico.
Mrs. L. Holbrook,	Mexico City, Mexico.
Miss Holbrook,	Mexico City, Mexico.
H. L. Hollis,	Chicago, Ill.
Charles W. Howard, Jr.,	Oakland, Cal.
Mrs. Emma S. Howard,	Oakland, Cal.
Miss Hyams,	Dorchester, Mass.
Mr. A. W. Jenks,	Mapimi, Mexico.
Mrs. A. W. Jenks,	Mapimi, Mexico.
Mr. W. J. Johnston,	New York, N. Y.
Mrs. W. J. Johnston,	New York, N. Y.
Edward S. Jones,	Scranton, Pa.
Mrs. Rufus C. Justis,	Fulton, Ill.
Mr. William Kent,	New York, N. Y.
Mrs. William Kent,	New York, N. Y.
C. Kirchhoff,	New York, N. Y.
George E. Ladd,	Rollo, Mo.
Carlos F. de Landero,	Pachuca, Mexico.
Pedro A. de Landero,	Pachuca, Mexico.
A. Laughton,	Mexico City, Mexico.
Mr. John Lilly,	Lambertville, N. J.
Mrs. John Lilly,	Lambertville, N. J.
Edwin Ludlow,	Baroteran, Mexico.
Mr. Frederick W. Lyman,	Minneapolis, Minn.
Mrs. Frederick W. Lyman,	Minneapolis, Minn.
Miss Lyman,	Minneapolis, Minn.
Mr. William R. McIlvain,	Reading, Pa.
Mrs. William R. McIlvain,	Reading, Pa.
Dr. Henry O. Marcy,	Boston, Mass.
Charles W. Miller,	Aspen, Colo.
Harry H. Miller,	New York, N. Y.
Mrs. R. B. Morison,	Baltimore, Md.
E. M. Nolan, Interpreter,	San Antonio, Texas.
Mr. E. E. Olcott,	New York, N. Y.
Mrs. E. E. Olcott,	New York, N. Y.

Miss Euphemia Olcott,	New York, N. Y.
Mrs. Neilson Olcott,	New York, N. Y.
E. L. Oliver,	San Francisco, Cal.
Mr. E. W. Parker,	Washington, D. C.
Mrs. E. W. Parker,	Washington, D. C.
Mr. W. S. Pilling,	Philadelphia, Pa.
Mrs. W. S. Pilling,	Philadelphia, Pa.
Miss E. J. Platt,	Scranton, Pa.
Mr. F. E. Platt,	Scranton, Pa.
Mrs. F. E. Platt,	Scranton, Pa.
Mrs. Joseph C. Platt,	Waterford, N. Y.
Robert E. Plumb,	Detroit, Mich.
Theodore D. Rand,	Philadelphia, Pa.
Jacob M. Rich,	New York, N. Y.
M. P. Rich,	New York, N. Y.
Mrs. George B. Richards,	Buffalo, N. Y.
Master G. B. Richards, Jr.,	Buffalo, N. Y.
Prof. R. H. Richards,	Boston, Mass.
Mrs. R. H. Richards,	Boston, Mass.
William H. Richmond,	Scranton, Pa.
Miss Emeline K. Richmond,	Scranton, Pa.
Miss Clara M. Richmond,	Scranton, Pa
Miss Laura Riegel,	Riegelsville, Pa.
Miss Ida Riegel,	Riegelsville. Pa.
Prof. Heinrich Ries,	Ithaca, N. Y.
Mrs. Heinrich Ries,	Ithaca, N. Y.
Thomas M. Righter,	Mount Carmel, Pa.
Miss Righter,	Mount Carmel, Pa.
Miss E. M. Rivinus,	Washington, D. C.
Mr. Charles Schäffer,	Philadelphia, Pa.
Mrs. Charles Schäffer,	Philadelphia, Pa.
Miss Sealy,	Galveston, Texas.
Miss Ella Sealy,	Galveston, Texas.
Mr. H. J. Seaman,	Catasauqua, Pa.
Mrs. H. J. Seaman,	Catasauqua, Pa.
A. W. Sheafer,	Pottsville, Pa.
George Singer,	Pittsburg, Pa.
Miss Lina G. Slee,	Poughkeepsie, N. Y.
Mr. J. William Smith,	Syracuse, N. Y.
Mrs. J. William Smith,	Syracuse, N. Y.
G. W. Steiger,	Washington, D. C.
Samuel Storrow,	New York, N. Y.
Mr. John E. Sweet,	Syracuse, N. Y.
Mrs. John E. Sweet,	Syracuse, N. Y.
Mr. F. M. Taylor,	Denver, Colo.
Mrs. F. M. Taylor,	Denver, Colo.
L. H. Taylor, Jr.,	Philadelphia, Pa
Mr. Edwin Thomas,	Catasauqua, Pa.
Mrs. Edwin Thomas,	Catasauqua, Pa.
Mr. Samuel Thomas,	Catasauqua, Pa.
Mrs. Samuel Thomas,	Catasauqua, Pa.
Mr. M. D. Valentine,	Woodbridge, N. J.
Mrs. M. D. Valentine,	Woodbridge, N. J.
Miss Anna T. Van Santvoord,	New York, N. Y.
M. A. Vielé,	Schenectady, N. Y.
Miss Weightman,	Philadelphia, Pa.
Charles H. Welles,	Scranton, Pa.

H. E. West,	Libby, Mont.
Mr. A. H. Wethey,	Butte, Mont.
Mrs. A. H. Wethey,	Butte, Mont.
L. H. Whitham,	New York, N. Y.
Mr. William H. Wiley,	New York, N. Y.
Mrs. William H. Wiley,	New York, N. Y.
Mr. David Williams,	New York, N. Y.
Mrs. David Williams,	New York, N. Y.
B. Williams,	San Francisco, Cal.
L. Williams,	Milton, Cal.
Mrs. L. Williams,	Milton, Cal.
Mr. Jones Wister,	Philadelphia, Pa.
Mrs. Jones Wister,	Philadelphia, Pa.
Miss Wister,	Philadelphia, Pa.
Mr. Oscar Wolff,	Baltimore, Md.
Mrs. Oscar Wolff,	Baltimore, Md.
Walter Wood,	Philadelphia, Pa.
H. H. Yard,	New York, N. Y.

It should be added that, besides the persons above named, the sessions of the meeting and many of the local excursions were attended by many of the 130 members of the Institute resident in Mexico, and by numerous other engineers and guests.

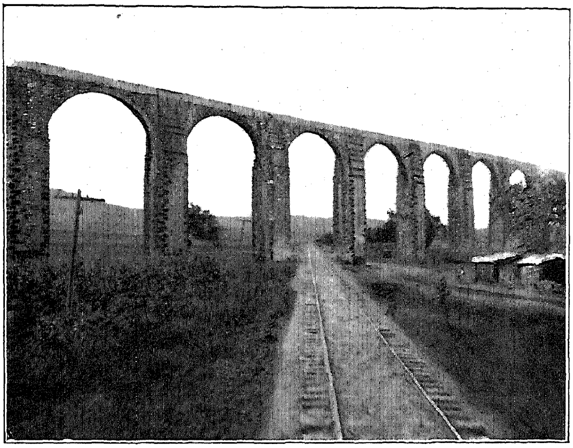
Chihuahua.

The party arrived at Chihuahua on Nov. 5th, at about 6 P.M., several hours behind schedule-time, by reason of the excessive weight of the two special trains, which are said to have been the heaviest that ever entered Mexico.* Notwithstanding this serious interference with the plans of the Local Committee, its programme was carried out with energy, night being turned into day for this purpose. On arrival at the railway-station, the party was immediately conveyed in carriages to the magnificent State Palace, where it was received by Governor Miguel Ahumada with an address of welcome in Spanish, to which President Olcott made an appropriate reply in the same language. The guests were then presented individually to the Governor. A large and excellent band, consisting of pupils of the School of Arts under 16 years of age, furnished appropriate music; and an elegant refection was served in an adjoining room.

A large part of the night, after 9 P.M., was devoted to a brilliant ball, given in honor of the visitors, in the *Theatro des*

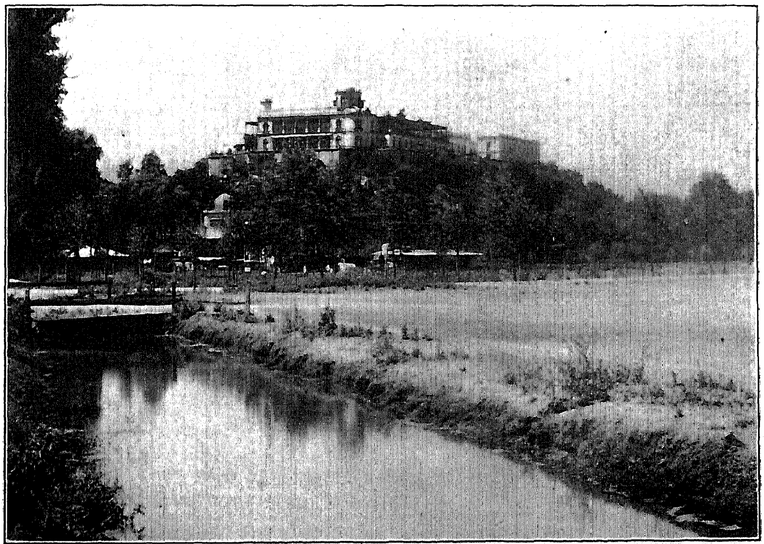
* In justice to the Mexican Central Railway Co., it should be said that nearly all this loss of time was incurred between Kansas City and El Paso.

Héroes, a handsome building erected by the State. The array of Mexican beauty and fashion presented on this occasion added



Aqueduct at Queretaro.

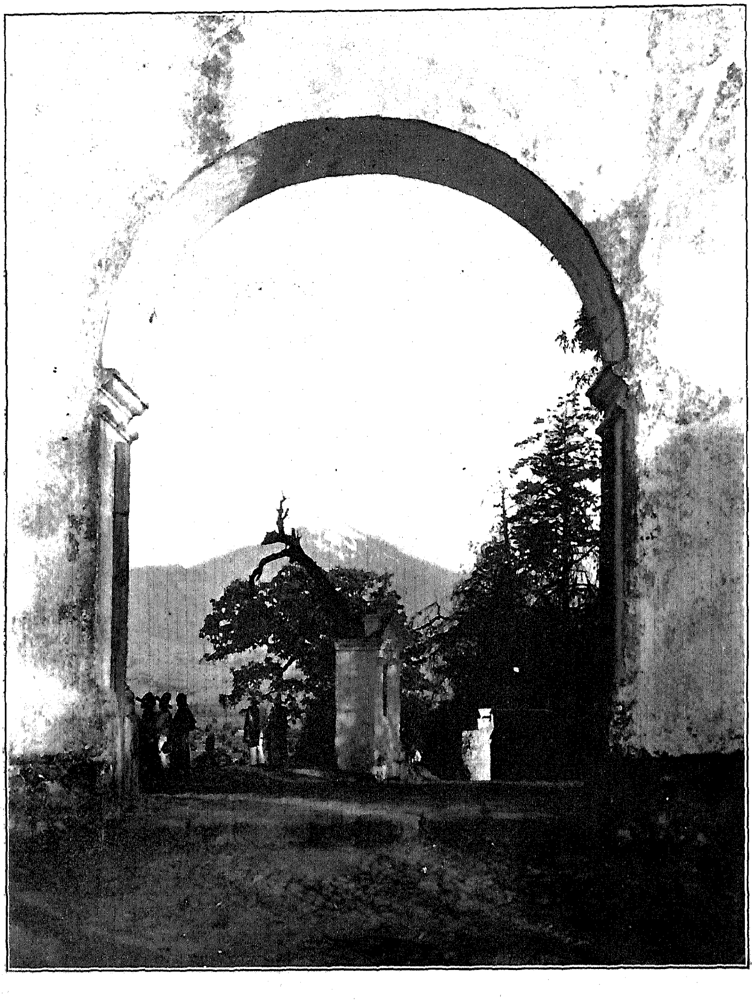
greatly to the splendor of the scene, and, together with the interesting novelty of the Mexican dishes served at the midnight



Chapultepec Palace.

supper, constituted a characteristic and impressive introduction to the hospitality of the Republic and its citizens.

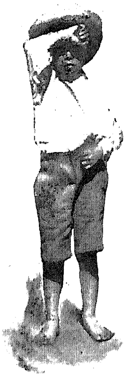
Wednesday, November 6th, was occupied with visits to points of interest in and about the city, conducted by English-speaking guides. Some of the party visited the *Descubridora* "manganese"-mine, a few miles distant, the ore of which car-



Popocatepetl, from Sacremonte.
(Photograph by Henry M. Stanley.)

ries $6 gold and 10 to 14 oz. of silver per ton, with 18 per cent. of manganese, 2 of iron, and 15 to 20 of silica, the remainder being carbonate of lime.

Coaches were provided by the Local Committee for the use of the visitors on all occasions.

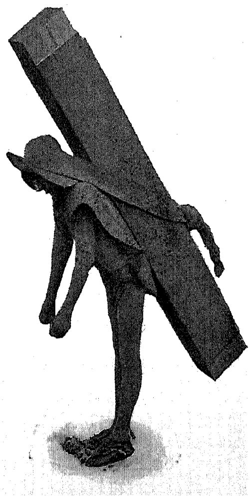


Special trains were provided by Messrs. C. S. Sheldon and A. S. Dash, managers, respectively, of the Chihuahua and Pacific and the Chihuahua Mineral railway of Santa Eulalia, to run to Miñaca and Santa Eulalia.

During the evening, the band of the School of Arts gave a promenade concert on the main plaza, which was elaborately decorated with flags and bunting, while the façade and spires of the Cathedral were brightly outlined and illuminated with innumerable twinkling lights. The smaller plaza in front of the Governor's palace was also illuminated, and the festive scene was full of picturesque and fascinating variety.

The adjectives of praise, admiration and thanks will necessarily be employed again in this narrative; but they will not have been in any later instance more thoroughly deserved than they were on this first notable occasion of the Institute trip in Mexico. The lavish and thorough preparations and the unwearied courtesy of Governor Ahumada and the Local Committee; the cordial co-operation of the citizens and ladies of Chihuahua; the interesting features and typical spectacles presented by the city, and the great historic, present and future importance of this State as a mining field, combined to establish Chihuahua in the memory of its guests beyond the danger of eclipse by any subsequent experience, however splendid.

From the pamphlet guide and programme furnished by the Local Committee, the following particulars have been condensed as worthy of preservation:

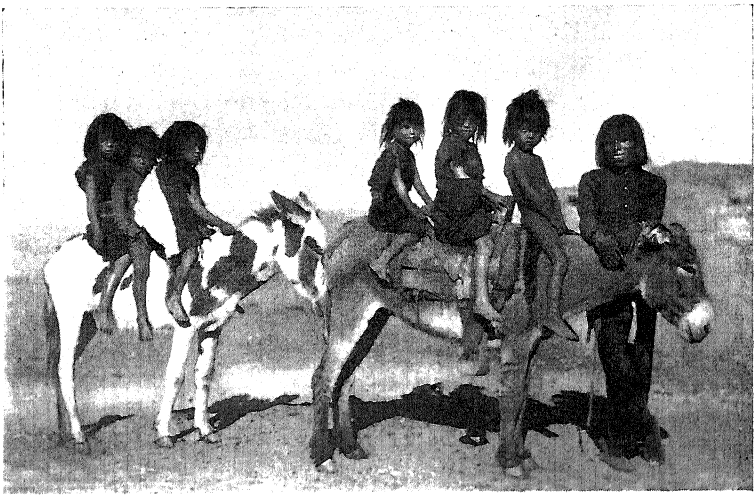


Chihuahua, a city of 35,000 inhabitants, and the capital of the largest State of Mexico, was founded early in the seventeenth century by the Spaniards, who worked the rich mines of the surrounding hills. Some of these are still productive.

Those of the Santa Eulalia district, 15 miles east of the city, have been in operation for 300 years, and are estimated to have produced silver and lead to the value of nearly $2,000,000,000. The present output is more than 300 tons of ore

daily, running from 30 per cent. of lead and 40 oz. of silver per ton to still higher values.

Chihuahua ranks first among the States of the Republic as a mining region. The present product of gold and silver bullion alone (not including ores shipped to smelters for treatment) exceeds $800,000 monthly, of which $250,000 is exported to the United States and England. The chief producers of silver bullion are the Batopilas Company ($180,000 per month); J. J. Waterson, Ocampo ($50,000); El Concheño ($56,000); Pinos Altos ($42,000); Santa Eduviges ($38,000); Belen Co. ($25,000); and El Refugio Co. ($24,000). Among the few properties in

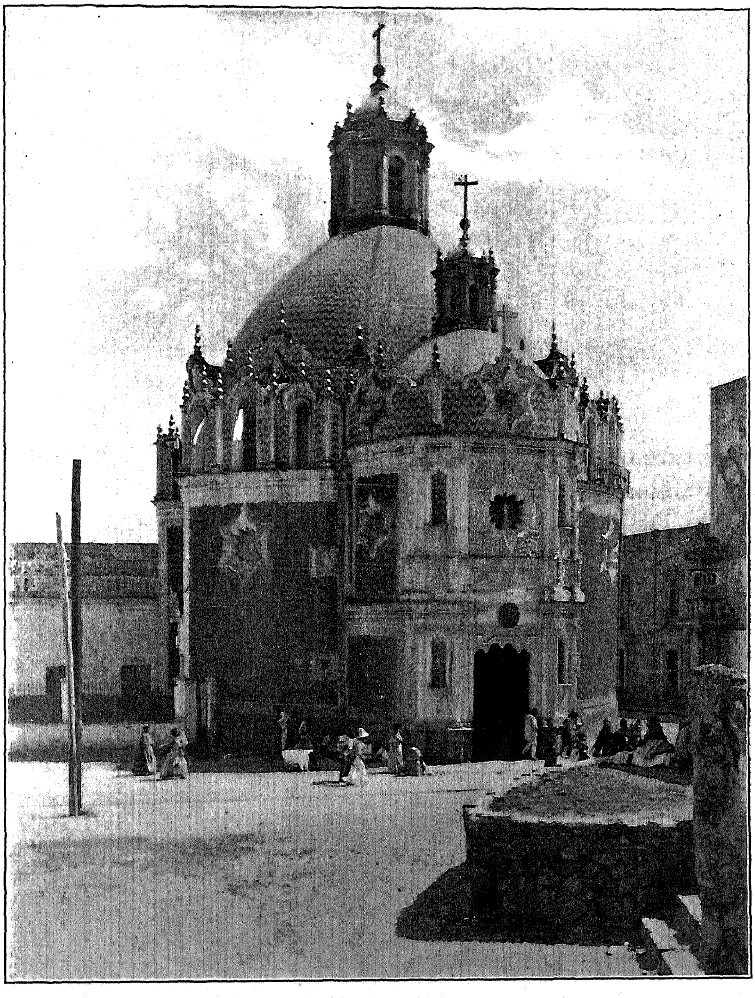


Study in Bronze.

this State which produce gold exclusively are La Gloria and Cerro Colorado, near Batopilas (reported to produce, together, $44,000 per month); the Guazapares mines (which have yielded in the past an enormous amount of ore, and have been purchased lately by a strong American company, with a view to extensive developments); and the Placer of Santo Domingo (likewise recently acquired by a foreign syndicate, which is now expending more than $500,000 gold in new machinery and plant). The largest known Mexican gold-nuggets have been found in the last-named district.

The principal mining camps of the State are Santa Eulalia, Parral, Jesús María, Batopilas, Guadalupe y Calvo, El Con-

cheño, Pinos Altos, Santa Barbara, Cusihuiriáchic, Magistral, Dolores, Guazapares, Morelos, Urique, La Descubridora, and Corralitos. The largest copper-mines are at Magistral and Guaynopita.



Chapel of the Well, Guadalupe. (Photo. by H. M. Stanley.)

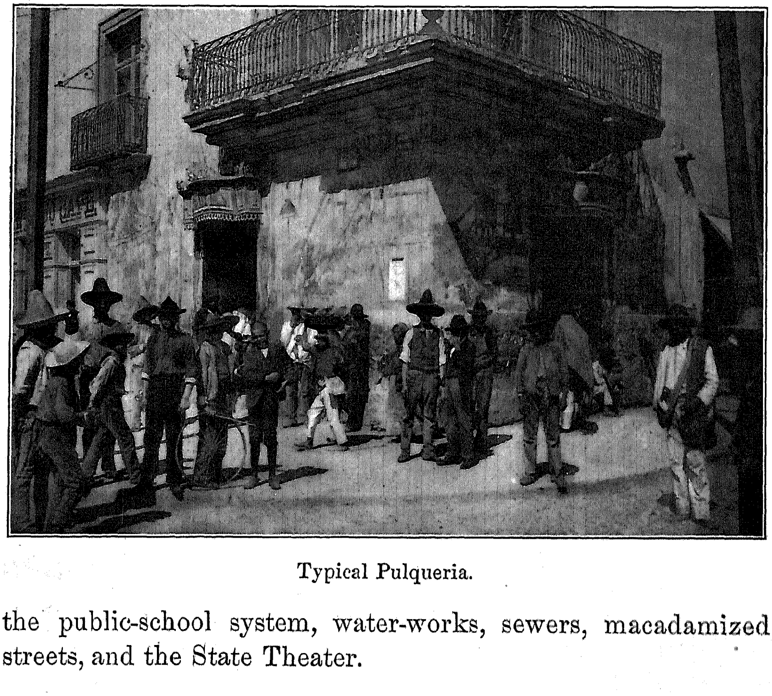
The construction of the proposed Kansas City, Mexico and Orient railroad is expected to increase greatly the productiveness of many districts.

For all these mining regions the city of Chihuahua is the distributing center, and their progressive prosperity will in-

crease its importance. Fortunately, under the able administration of Governor Ahumada (who is now serving his third term),

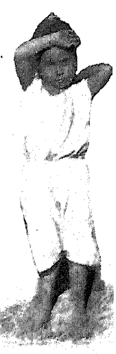
First Shrine in Mexico City.

the future of the city has been worthily provided for by the introduction of modern municipal improvements, among which may be specially mentioned, as due to his wisdom and energy,



Typical Pulqueria.

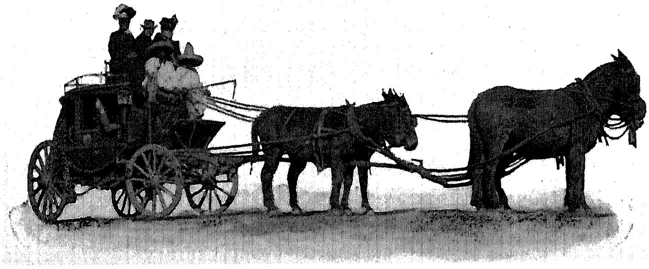
the public-school system, water-works, sewers, macadamized streets, and the State Theater.



The city contains a number of important industrial establishments, including the large La Paz textile-mill; a fine brewery; a very extensive meat-packing and canning factory (with capacity to handle 300 head of cattle per day); and, most interesting of all to members of the Institute, the iron- and steel-works of *La Compania Industrial Mexicana*, of which the following account is taken from the *Iron Age* of Nov. 21, 1901:

"La Compania Industrial Mexicana is under the management of Juan A. Creel, an exceedingly progressive and alert Mexican, a native of Chihuahua, who, with his brother, Enrique C. Creel, is identified with the different industries and with extensive mining enterprises. Mr. Creel, who was partly educated in the United States, began his career in a local bank, and has now, at the age of 35, reached the point where he can work out his patriotic desire of devoting his abundant energies to the uplifting, from an economic point of view, of his countrymen and to the development of the extensive, though still largely dormant, resources of the State. Mr. Creel took hold of the Compania Industrial Mexicana in 1893, when the plant consisted of a small foundry and machine shop. Under his management it has prospered and grown, and is still expanding rapidly. A most interesting feature of much significance which has taken place simultaneously with this development is the education of native labor to the rank of skilled artisans. In 1893 the Mexicans were employed only as common laborers. To-day, when running full, the plant has 550 men on its pay-rolls, of whom all but about 50 are natives. They have taken their places as molders, pattern-makers, machinists, rollers and melters, callings unknown to them until now. They are paid the same wages as those earned by the American mechanics, the machinists receiving $3 to $5 per day, Mexican money, while the pattern-makers earn as high as $6, Mexican, per day,—wages which, in gold, are about on a par with those paid in the United States.

"The plant consists of a 15-ton Wellman tilting basic open-hearth furnace, equipped with a Wellman charging machine, the steel being cast into groups of small ingots on cars, bottom-casting having been adopted. The two bottom runners are of such dimensions that after the sprues are cut off a 4-inch billet is produced, which can be rolled into shapes for which an absolutely perfect surface is not necessary. The pig-iron is purchased in the United States, but the works use largely old car-wheels, and, of course, depend upon the country for the



wrought scrap. Purchased muck-bars are the raw material for such iron bars as are rolled.

"The rolling-mill, which is equipped with a modern heating-furnace, has a 12-inch and an 8-inch train, and produces bars down to $\frac{1}{8}$-inch rounds. It is driven by two engines, both of which were built in the works.

"There is a large foundry and a good-sized machine-shop, crowded with American tools, although a number of the tools were made in the shop. The company make a specialty of mining machinery, stamp-mills, slag- and metal-pots, etc., and build Corliss engines up to 1000 horse-power. In the shops, in course of erection at the time of the visit of the engineers, was a 1000 horse-power horizontal Corliss compound engine for an electric plant. The foundry makes also miscellaneous castings, and quite recently the manufacture of stoves has been taken up. There is a brass-foundry and a special department for the manufacture of valves, this being the only plant of its kind in Mexico. All the parts of the plant outside of the rolling-mill are driven by electric motors, the engine being a product of the shops. There is now in course of erection a new electric plant,

At Real del Monte.

Lodgings for Man and Beast.

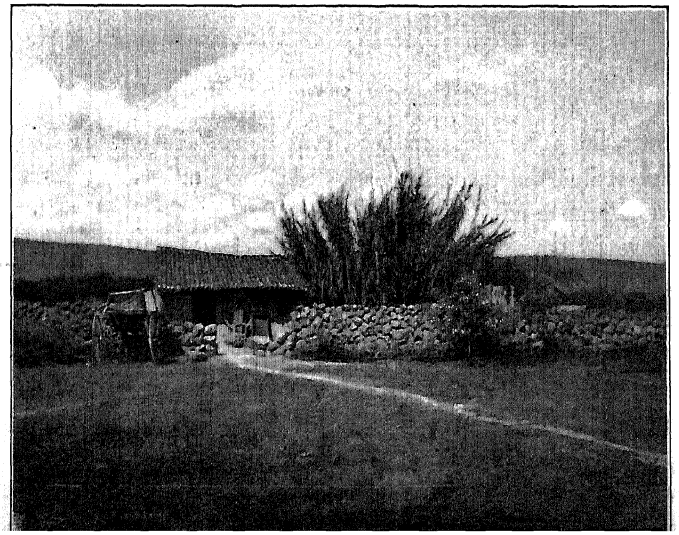
(Photo. by Cox & Carmichael.)

housed in a building the structural work of which was furnished by the American Bridge Company. It is large enough for an equipment of 10,000 horse-power. The present electric installation is supplying the town with light, but has reached its limit of capacity in that direction. The fuel used for the boilers is wood and coal, the latter costing $12 per ton for Mexican and $18 for American coal. The plans are being drawn for a very large new machine-shop, the old one having outgrown its quarters.

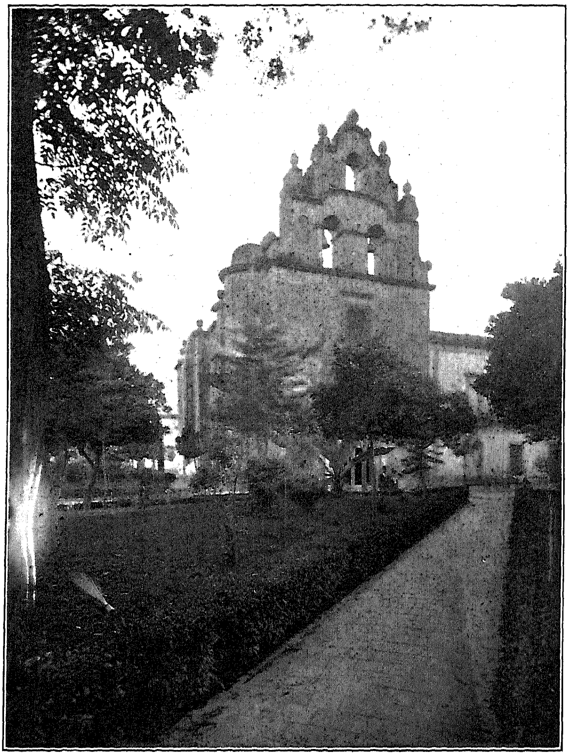
"Friends of Mr. Creel relate a recent experience which illustrates both his enterprise and the difference between foreign and native management. At a short distance from Chihuahua is a copper-mining property which has passed through the hands of several English companies, the last having spent about $1,000,000. As an indication of the chararter of the work done, the fact may be cited that the slags made by the smelter ran 2 per cent. of copper. The property, being regarded as a complete failure, was hawked about in vain. Mr. Creel finally purchased mines and smelter for $25,000, Mexican money. He put in new machinery at the smelter and made improvements which cost in all $92,000, Mexican currency. In 14 months the entire outlay had been recovered, and the company, known as the Rio Tinto Mexicana, is earning handsomely."

Parral.

Delegations from the Local Committee boarded the two sections of the excursion-train *en route*, early in the morning of Thursday, November 7th, and many miles away from their stopping-place. Reaching Parral at 11 A.M., the party was met by the remainder of the Committee, with a brass band, at



the railway station. After an address of welcome from the Mayor, Sr. Don Tito Arriola, they were divided into three parties, one of which, under the guidance of Mr. Edward Du-



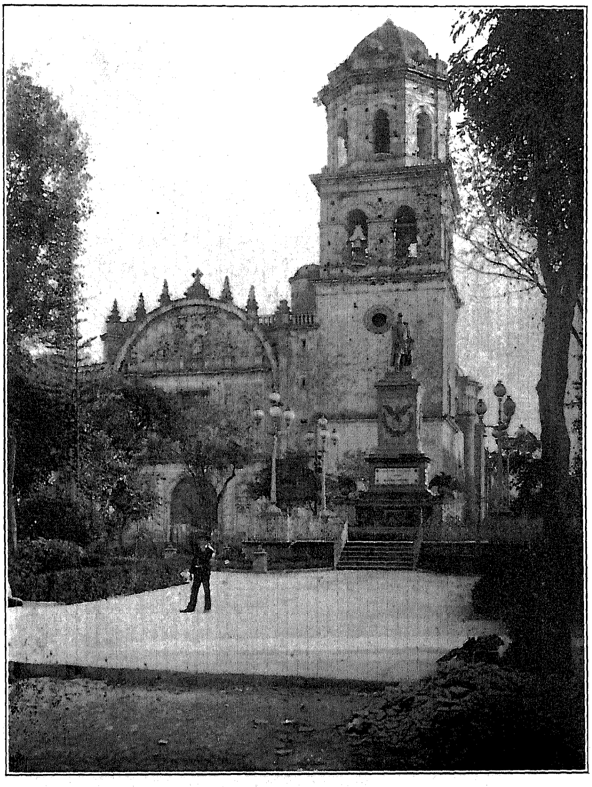
Chapel of Aranzazu, Guadalajara.

fourc, the American superintendent of the Montezuma Lead Co., visited the Santa Barbara district (15 miles from Parral, on a branch of the Mexican Central railway); another was conveyed over the Parral and Durango narrow-gauge railway to Minas Nuevas; and the third inspected the mills and other points of interest in and around the town itself.

At 4 P.M. the three parties were reunited and conducted, through a vast crowd of peons in picturesque costume, to the *Bodega*, a large warehouse, which had been emptied, re-plastered, kalsomined and decorated in their

honor, to partake of an elegant banquet, for the several courses of which sundry distant localities had been drawn upon. Oysters came from Corpus Christi; fish from Tampico, on the coast of the Gulf of Mexico; and strawberries from Irapuato.

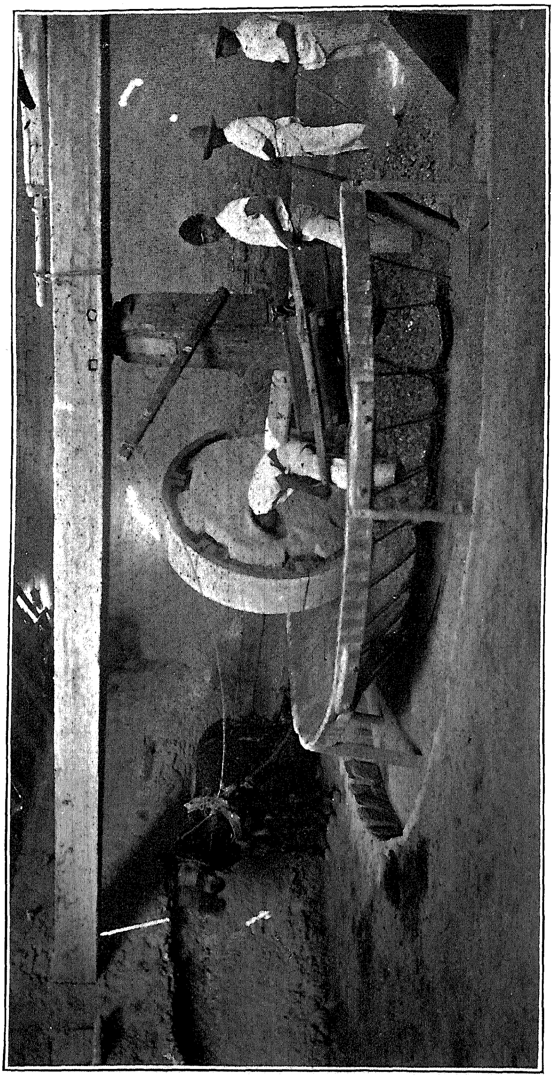
On entering the spacious hall thus extemporized, the guests



Church of San Francisco, Guadalajara.

were showered with *confetti* by the ladies of the city, while the band played "The Star-Spangled Banner."

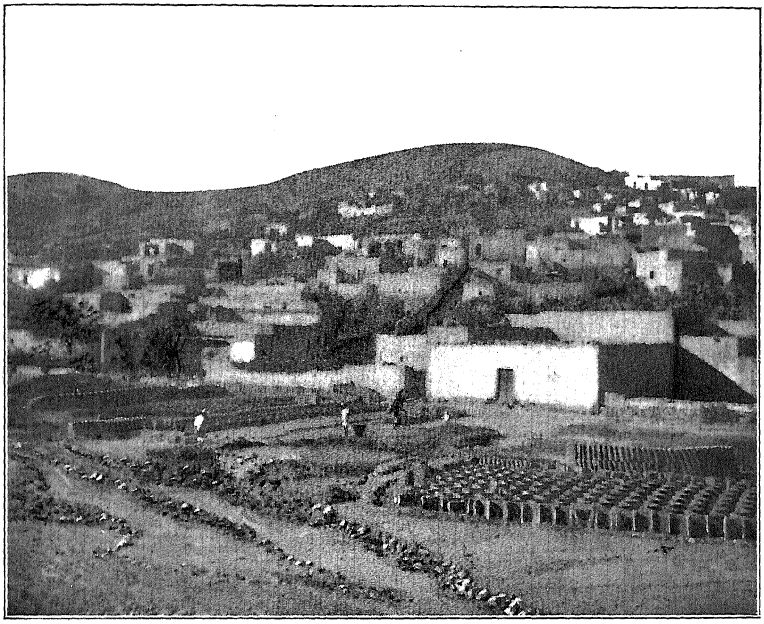
Here, as in many other places in Mexico where the representatives of the Institute were entertained, the portraits of Hidalgo, Juarez and Diaz, who occupy in the history of that



Chilean Mill Run by Mule Power at Guanajuato.

Republic places of honor and esteem corresponding to those of Washington, Lincoln and McKinley in the United States, were prominent among the festal decorations. This fact was gracefully utilized by Sr. Don Felipe Arellano, member of the

National Mexican Congress, who, as the appointed representative of the municipal authorities and the Local Committee,



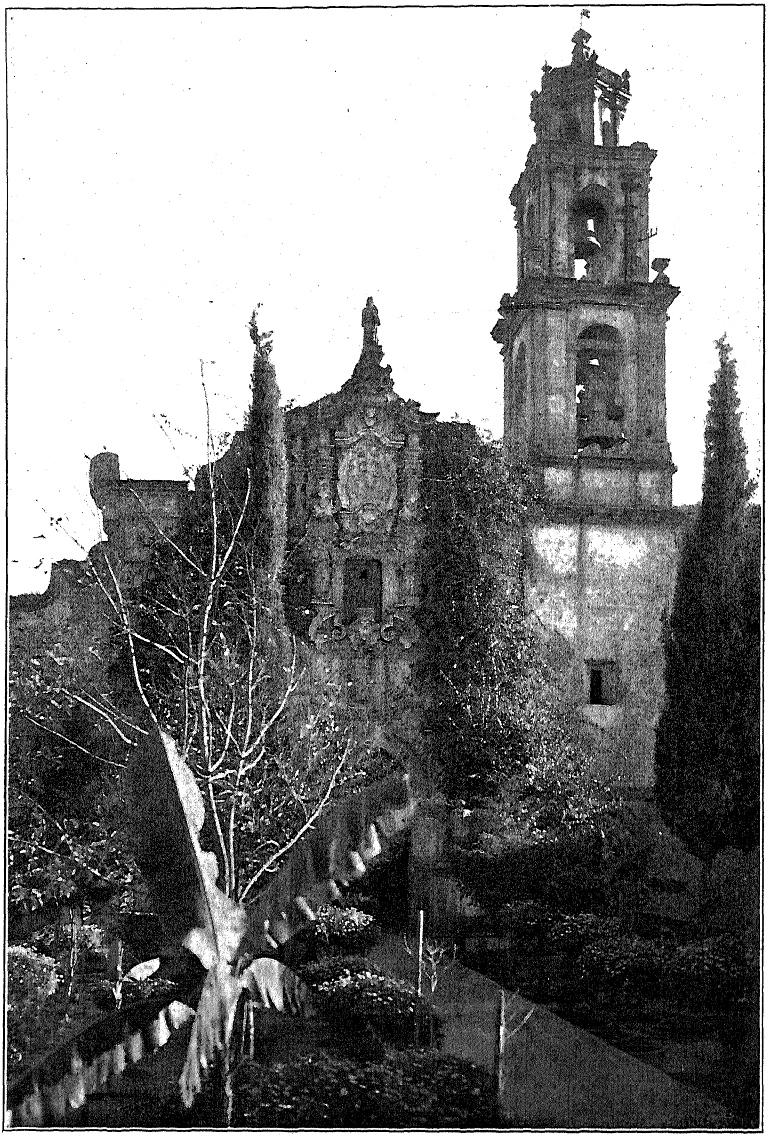
Making Adobe Bricks, Guanajuato.

offered at the close of the banquet, and in the English language, the following address and toast:

"*Ladies, Young Ladies, and Gentlemen:* I am not going to make a speech; there is not time for that, and I am not master enough of the English language to say all that ought to be said on this occasion.

"Appointed by the first political authority of this city to offer you this ban-

quet, I will only say a few words to you, to express, if my lacking knowledge of the language of Shakespeare allows me to do it, the gratitude of the inhabitants of this mining district for your kindness in coming to visit our mountains.



San Francisco Church at Marfil.

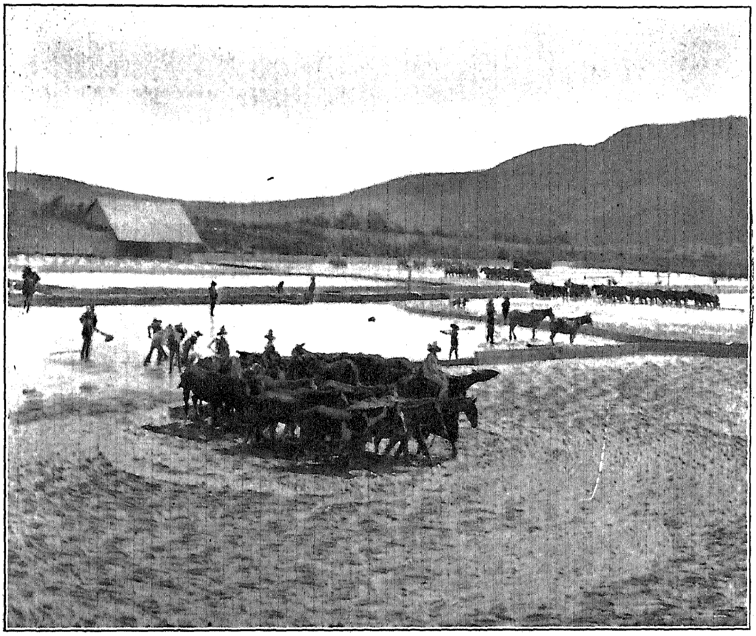
"Yes, the miners and merchants of this city and its neighborhood feel themselves very happy to see you here; and they tender to you their most warm thanks for your visit. Everybody here has felt happy and honored to shake

hands with you this morning, and hopes that this visit of some of the most distinguished engineers of the United States will be of great benefit to this mining district. Please accept, then, our thanks, and the assurance that your short stay here will be always remembered with pleasure.

"Please have the kindness to accept, too, this poor banquet as a token of our good will. We know that it is really poor; but we hope that you will accept it so, taking into consideration our lack of proper means to receive and to entertain such distinguished guests as you are.

"Please, too, accept the little silver spoons and the historical book of our town and mines, which an especial commission is going to put in your hands before we leave this table, as a testimony of our high esteem and gratitude to all of you.

"And now, distinguished Ladies and enlightened Gentlemen, Good-by, Good-



The Patio Process.

by to you all! May God bless your way wherever you go; may fortune and happiness be always your lot in the struggles of life; and when you return home, when you kiss again the flourishing and rosy cheeks of your little ones, turn back your looks towards Mexico, and then remember, and never forget, the new but true friends that you leave in Hidalgo del Parral! But, then and now, forget and forgive the imperfect use that I have just made of your sweet and native language.

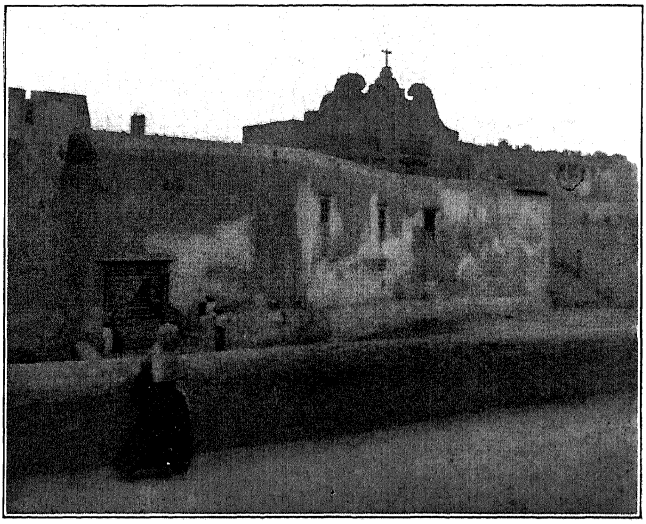
"Now, let us drink to the United States, the country of Washington, father of freedom in America, and of Lincoln and McKinley, the two great, courageous and glorious redeemers from slavery; not only the United States, but also Cuba, Puerto Rico and the Filipinas; to Mexico, the country of Hidalgo, Juárez and Porfirio Díaz; to the two sister Republics, the first on the American Continent and in a great part of the civilized world; to General Porfirio Díaz, President of

Mexico, the great warrior and statesman, who in a short period of time has raised so high the name of the Mexican Republic; and to Colonel Theodore Roosevelt, the brave leader of the 'Rough Riders' before the walls of Santiago de Cuba, and now the able President of the United States of America!

"*Señores: Digamos ahora todos, en el magestuoso idioma de Cervantes:* VIVA LA FRATERNIDAD UNIVERSAL!"

A suitable response to this eloquent address was made by President Olcott; and the remainder of the day, together with the early evening, was spent in informal social entertainments, including a visit to the Casino, where a ball was in progress. At 9 P.M. the special trains left Parral.

The "historical book" mentioned in the address above quoted was a beautifully illustrated souvenir, entitled *Hidalgo*



At Marfil.

del Parral, a Mining District Abounding in Mineral Wealth, Indian Legends and Interesting Superstitions, from which the following

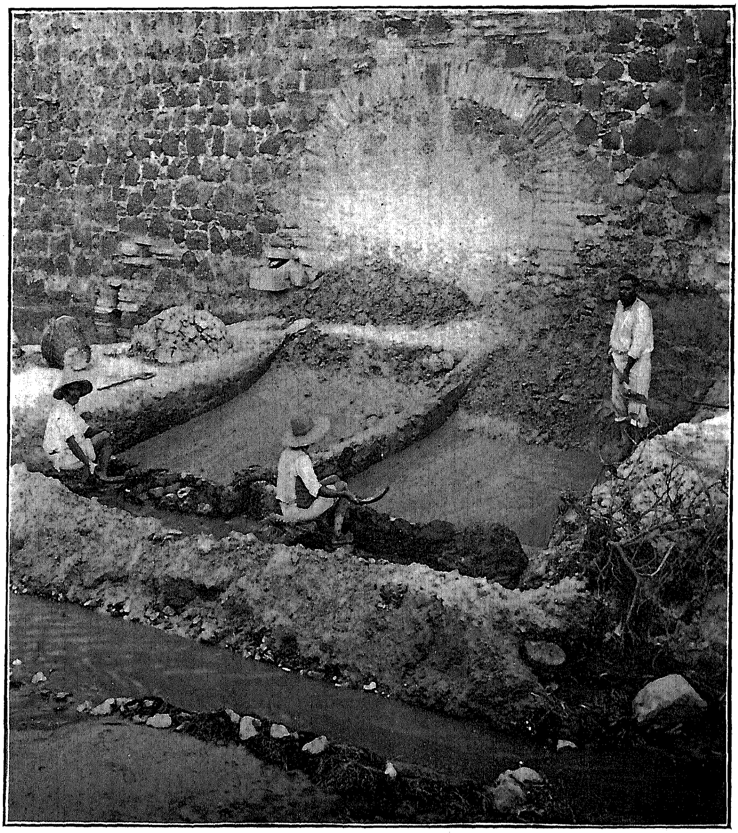
account has been condensed, with the insertion of some additional remarks from other sources:

The exact date of the first discovery of ore in Parral cannot be fixed. That it was before 1652 is proved by a report of that date by the Alcalde, Capt. A. Guerra, which mentions 29 mines as working in what was evidently the mine now called the *Jesús María*, and 14 in the "*Negrita*," evidently the present *Tajo*. The town-record of mines and denouncements (locations) for 1632 shows great activity in mining at that period. All the municipal records earlier than 1612 are lost; but it is known that the town was established considerably before that date.

Prior to 1634 the mines were worked for gold only; but in that year Gov. Don Gonzalo Gomes de Cervantez reported to the Marquis of Sinaloa that ores had been discovered carrying 12 oz. of silver per 100 lbs., and that some of these could be successfully amalgamated, while others must be smelted. The records of 1634 show 4 amalgamating-works and 20 smelters in operation.

In the Parral assay-office, the record from 1641 to 1847 shows 569,741 *marcos* (or 4,557,741 oz.) of silver; and it may be inferred that after a few years of decline, between 1634 to 1641, there was a considerable revival of the industry. From 1649 to 1688, however, the registry of only 313,472 *marcos*

(2,507,776 oz.) of silver indicates another decline. Such fluctuations are doubtless due to the fact that, with the crude early methods of mining and reduction, only very rich ores could be mined with profit, so that the condition of the industry depended from year to year upon the opposing factors of the exhaustion of old *bonanzas* and the discovery of new ones, rather



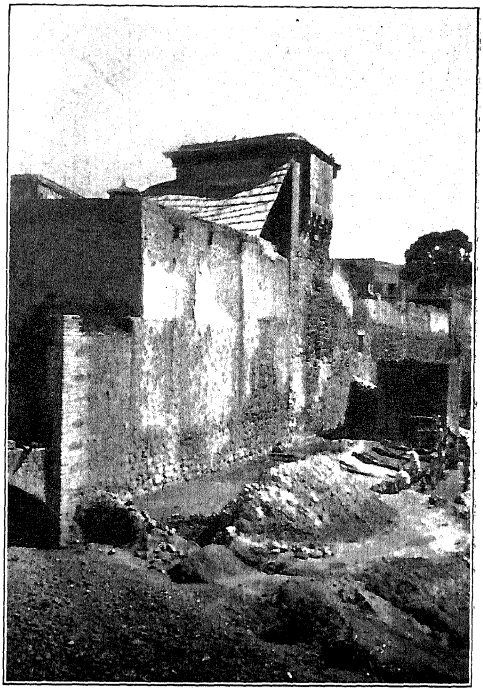
Washing Tailings.

than upon the systematic and continuous working of the same mines.

The old records from 1688 to 1718 were destroyed by the French during their intervention in Mexico, a century and a half later; and only a few facts can be now gleaned from the remaining documents.

It may be inferred from the records that from 1718 to 1820

the immediate vicinity of Parral maintained a considerable output, mostly or wholly from shallow workings. The later records of this period frequently refer to Parral as containing ores of low grade but boundless quantity. What was meant by "low grade" at that time seems to be indicated by the statement (in a petition for the establishment of suitable reduction-works) that the ores contained only 12 oz. of silver per *carga* of 300 lbs.—or, say, 80 oz. per ton!



Guanajuato.

It is hoped that a full account of the ore-deposits and mining industry of this district, prepared by a competent hand, will be published hereafter in the *Transactions* of the Institute. Meanwhile, the following scanty notes are reproduced from the little book of the Local Committee.

Parral is located in the foot-hills of the Sierra Madre, the main range of which forms an imposing background to the series of successive elevations which ascend, step-like, from Jiminez, on the great Mexican plateau. From this place a branch of the Mexican Central railroad runs to, and about 60 miles beyond, Parral. With the completion of this branch to Parral, about three years ago, the present revived activity in mining began. Previously, ores were hauled by wagon to Jiminez, and shipped thence to Socorro, N. M., El Paso, Texas, or Mapimí, Mex., for treatment.

In the immediate vicinity of Parral the general rock is "porphyry," which contains strong and well-defined veins, carrying siliceous silver-ores low in lead. Large bodies of low-grade ore, formerly not profitable, will now be mined by economical modern methods and machinery, and concentrated or reduced in the district. It is reported that the mills completed during the last two years, or now under construction, have a capacity of 1200 tons of ore daily.

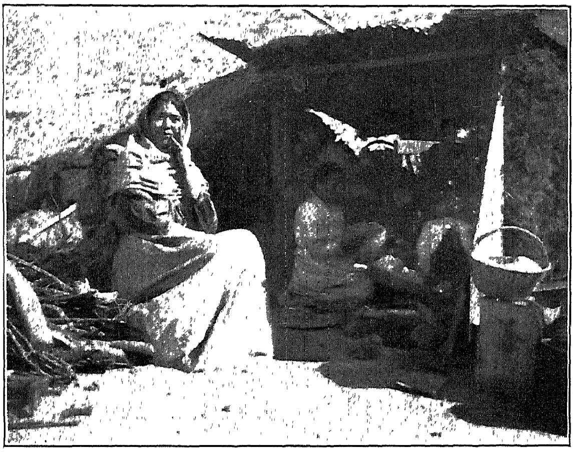
Santa Barbara.—This place, 10 m. SW. of Parral, in the most important part of the general Parral district, is the oldest camp in northern Mexico. It was founded in 1547 by Spanish explorers, who are reported to have opened ten gold-mines, producing from 12 to 14 oz. of gold per *carga* of 300 lbs. (= 12 *arrobas* of 25 lbs.), supplying 700 *arrastres*, and supporting a population of 7000. In 1580, Santa Barbara was the seat of the Spanish viceroy, who ruled over what is now the western and southwestern part of the United States, as well as the northern part of Mexico.

San Luis Potosi.

Early in the 17th century the prosperity of Santa Barbara seems to have been interrupted by a general "stampede" of miners to the new district of San Diego de Minas Nuevas—now simply Minas Nuevas—of which mention is made below. The official records have little to say of the older camp for some two hundred years. It is noted that early in the nineteenth century foreign capital was invested, especially in the Mina del Agua, which was sunk 60 ft. below the water-level, and then abandoned. (In 1892 this

mine was reopened by a foreign company, which realized from it in a few months, and with small outlay, a net profit of more than $80,000.) There are also allusions to extensive gambocino ("gopher") workings on all of the larger veins, which proved, as usual, profitable to the operators, but ruinous to the mines and the camp.

The general country-rock at Santa Barbara is slate and shale, traversed by N.–S. veins, dipping 45° to 75° E. Of these, the Tecolotes and the Mina del Agua can be traced for 3 or 4 miles over the mountains. Pockets of very rich gold-ore were found near the surface; but below the oxidized zone the grade was much lower, though the quantity of ore is large and regular.



Making Tortilla.

Minas Nuevas.—The origin of this camp was later than that of Santa Barbara, but doubtless considerably earlier than 1645, which is, however, the first date of a mining location now accessible in the books at Parral. In 1657 there were fourteen competing ore-buyers in the camp—a proof of considerable production at that time. The first mine in the district is said to have been the *Veta Grande*, located on the *Veta Colorado*, which is the strongest vein in the district, and, perhaps, in Mexico. Its outcrop is plainly traceable for ten miles over the mountains, and averages, so far as it has been developed, 500 ft. in width. The deepest mine on this vein is the *Veta Grande*, the incline of which has reached the depth of 1250 ft. (about

1000 ft. vertically), and shows at the bottom a vein from 15 to 18 ft. wide, assaying from 40 to 50 oz. gold per ton. Other old and new mines on the vein are the *San Francisco de la Mereña* (700 ft.); *Nopal* (700 ft.); *Preseña* and *Alfareña* (900 ft.); *Biscayna* (about 600 ft.); *El Verde* (about 1100 ft.); *Los Muertes* (680 ft.); *Pachuqueña* (700 ft.); and the *Quebradillas*, the south end of which has been worked to the depth of 550 ft.; while the north end, opened within the last 10 years, and now in *bonanza*, is 725 ft. deep. (The figures above given all signify inclined depth, unless otherwise specified).

The Brute and the Burden.

The ores from this vein are red with iron oxide—whence the name *Veta Colorado.*

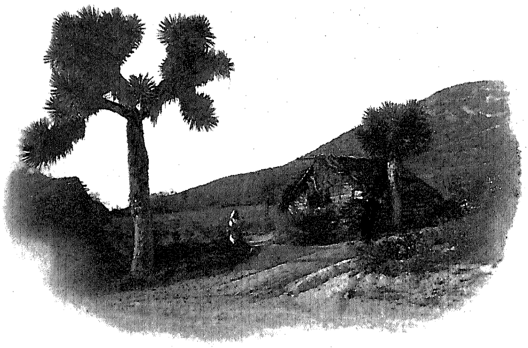
Zacatecas.

On Friday, November 8th, at 4 P.M., the party reached Zacatecas. At this place no official reception had been arranged; but a stop of some three hours enabled the guests to see the quaint and interesting old city; and a small number of them visited a neighboring mine. Zacatecas lies at an altitude of 8000 ft., has 45,000 inhabitants, and was founded in the middle of the sixteenth century. The district is said to have produced, from 1548 to 1810, gold and silver to the value of nearly $10,000,000.

The City of Mexico.

The capital was reached at 4 P.M. on Saturday, November 9th. Among the numerous visits and social entertainments offered to the Institute during the meeting were the following:

Monday, November 11th.—Inspection of the Library, Hall of



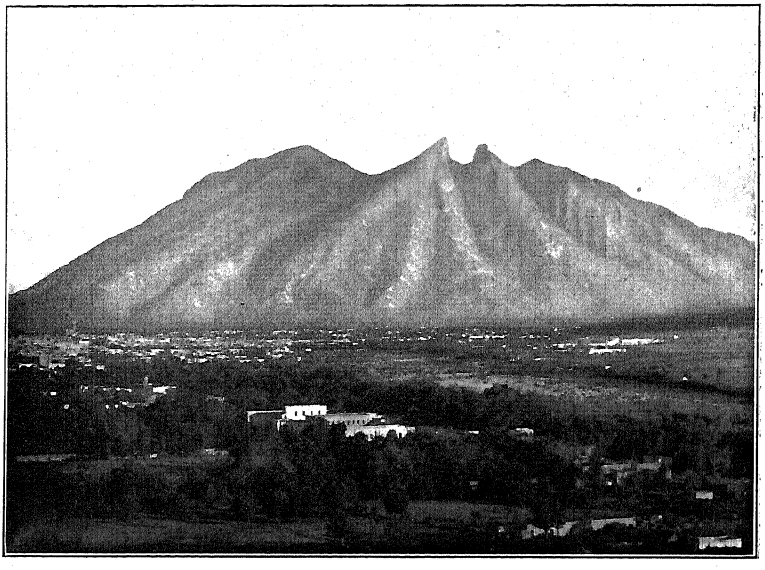
Models, Meteorological Observatory (commanding a magnificent panoramic view of the city), and Mineralogical and Geological Cabinets of the School of Engineers; visits to the National Library, the Cathedral, etc., and (in special electric cars) to the suburbs.

Monday Evening.—Reception given by the *Ayuntamiento* ot the City in the Municipal Palace.

Tuesday, November 12th.—Visit to the National Museum and the Academy of Fine Arts. Reception by President Díaz in the beautiful castle of Chapultepec (built by the Viceroy of Bernardo de Galvez, and completed by the Emperor Maximilian). Visit to Guadalupe; inspection of the sampling- and testing-works of Heckelmann & McCann (the only establishment in Mexico where experimental working-tests for the concentration and metallurgical treatment of ores are made). In the evening, a reception and ball at the American Club, given by the American residents of the City.

Wednesday, November 13th.—Special excursion via the Hidalgo and Northern railway to inspect the great drainage-works of the Valley of Mexico,

recently completed. From the City to San Cristobal, where the railroad crosses the canal, the party were the guests of Sr. Don Gabriel Mancera, the owner of the road. At San Cristobal they were taken in charge by Sr. Don Luis Espenosa, chief engineer of the contracting company which built the works. In the afternoon, a banquet, provided by the Local Committee, was served at Zumpango. The table was decorated with flowers, and a series of large glass vessels, containing the three famous red, white and green national varieties of *pulque*

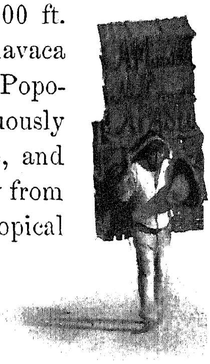


Saddle Mountain, Monterrey.

punch, flavored respectively with the juice of the prickly pear, almond and celery. The *menu* was composed of Mexican dishes.

Wednesday Evening.—Musical Reception and Tea, tendered by the railway, banking and mercantile circles, and the engineers of the City, at the restaurant in the gardens of Chapultepec.

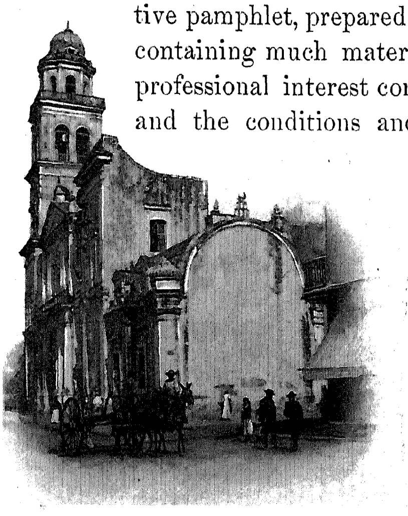
Thursday, November 14th.—Special excursion over the Mexican, Cuernavaca and Pacific railroad to Cuernavaca, in the State of Guerrero. This is one of the famous scenic lines of the Republic. After crossing the valley of Mexico, the road ascends the mountain-side, traversing the lava-beds, to an alti-



tude of 10,400 ft. Then it drops rapidly 5000 ft. into the rich valley of the Morelos, with Cuernavaca in the center. The snow-capped peaks of Popocatepetl and Ixtaccihuatl are almost continuously in sight. The town is in the tropical zone, and the last 75 miles of the trip brought the party from the temperate climate of the plateau to the tropical plain, with its sugar plantations and coffee trees. The chief attractions were the Borda gardens, commenced in the middle of the last century by a French miner, and still very luxuriant and attractive, though their fountains and terraces show the results of long neglect. The plaza, market-place, old Cortez palace, and other ancient buildings at Cuernavaca, are very interesting. The railroad has been completed through the Igualo cañon to the Balsas river, which it will follow to the Pacific at Zihuatanejo, thus opening to commerce the dormant mineral resources of the State of Guerrero and the agricultural section of the State of Morelos.

The excursion-party returned about 9 P.M. to the City of Mexico; and at midnight the special trains departed for Pachuca, which was reached early on Friday morning.

During their stay in Mexico, the visitors were furnished with a guide-book to the city and *environs*, and an admirable descriptive pamphlet, prepared by the Local Committee, and containing much material of historical, scientific and professional interest concerning the localities visited, and the conditions and prospects of the Republic.



The greater part of this material will be found in the two following papers, by members of the Institute, which will be separately published in the usual way, as personal contributions to the *Transactions:*

"The City and Valley of Mexico," by Prof. Ezequiel

Ordoñez, Sub-Director of the National Geological Institute, Mexico, Mex.

"A Sketch of Mexican Railroads," by Victor M. Braschi, Mexico, Mex.

Pachuca.

Early in the morning of Friday, November 15th, the two trains arrived at Pachuca, the home of Sr. Don Carlos F. de Landero, a Vice-President of the Institute, and the leading spirit in the reception of his fellow-members throughout the Republic. Pachuca is famous also in the history of Mexican mining, and especially as the birthplace of the *patio* process.

The travelers were awakened at 7.30 by the strains of a military band, and, upon leaving the cars, were cordially welcomed by the Local Committee, headed by the Mayor, Sr. Don Rodolfo Munoz, and conveyed in carriages to the Palace, where, at 8.45 A.M., they were received by His Excellency, the Governor of the State of Hidalgo, who, by the way, spent his time almost exclusively for the next two days in cordial contributions to the entertainment of the guests. After an exchange of addresses, and the distribution of programmes, etc., containing useful information, the party resumed their carriages (vehicles of various capacity, drawn by from 4 to 11 mules each, and collected from a large region, to meet the special demand for transportation) and were driven 3½ miles to the Santa Gertrudis mine, 2000 ft. above sea-level, where extensive preparations had been made for their reception. Those who desired to go underground were conducted into the mine-workings. There are five principal shafts for hoisting and pumping, respectively 242, 245, 470, 420 and 202 meters deep. The absence of timbering and the protection by arches of masonry of all drifts, etc., not in solid rock, is an interesting feature of this and other mines of the district. This mine has produced since 1878 about $25,000,000 (Mex.) in silver.

The most remarkable sight above ground here is the new Cornish pumping-engine, built in 1898 by Buckle & Co., Limited, of Plymouth, England, which was, at the time of this visit, ready to begin to run regularly, but had been run, in fact, but a few hours. The *Engineering News* of Nov. 28, 1901, gives the following description of it:

"The steam cylinder is 90 in. in diameter and 10 ft. stroke, and its pump-plunger 9 ft. stroke and 18 in. diameter. The pump-rods are 500 meters, or 1600 ft., long. Its capacity is 1000 English gallons per minute, or, translated into American terms, about 1,750,000 gallons in 24 hours.

"This enormous engine is said to have cost over $100,000 gold. It requires a large house to contain it; and, besides, it requires a special steam capstan—a large drum driven through a worm-gear by a double upright engine—to erect it or to remove its parts for repairs. The engine has the old Watt parallel motion and the cataract valve-gear of the eighteenth century. An engine of this type has probably not been built in the United States, except possibly in California, for over 30 years, but it appears still to be built in England. The only reason for its being in this mine is that its former management was English. The present owners and managers are Mexicans, and they would not have bought such an engine. Matching the engine in out-of-dateness is a new battery of Cornish boilers; but these we did not see, as they were covered over with a floor, to make the boiler-room into a banquet hall for our entertainment."

A sumptuous banquet, served in the great boiler-house of the mine, which had been specially floored to accommodate 400 guests, was followed by numerous enthusiastic speeches in Spanish and English, of which the following, delivered by Captain Tomas Soloman, is preserved as containing much valuable information:

"*To the Visiting Members of the American Institute of Mining Engineers, their Families and Friends:*

"*Ladies and Gentlemen:* It is with much pleasure that we welcome you to Santa Gertrudis, and we heartily thank you for the honor you have conferred upon us in coming into our midst to-day. We hope that your visit to Pachuca will be both an agreeable and profitable one, and that your general tour will be successful in every respect, and that you will take away with you many happy impressions and remembrances of this sunny land.

"I have been requested to give you a brief outline of the history of this ancient and justly renowed mining district, and principally of this property on which you are now standing, and which is one of the most important mining propositions of this country. I have also been asked to express my views of Mexico and her people.

"The records we have of the oldest mines in this vicinity we owe, perhaps, to the researches of Humboldt. Another authority, however, Mr. W. P. Robertson, has made the statement that those of Real del Monte had been worked fully three hundred years before the advent of Don Pedro José Romero de Terreros, an enterprising Spaniard, who was afterwards created Conde de Regla. He came in 1749, and several years of prosperity were the fruits of his administration. After his death, adversity came to his heirs, and the liabilities on the mines increasing, they found it convenient, in 1824, to enter into a contract with the English Taylor Co., with the result that the mines were leased to this powerful and widely known corporation for a period of twenty-one years. This company, with ample capital at their back, entered with expensive enthusiasm into the work of development, and in the following year, 1825, three ships, each of 300 tons burden, arrived at Vera Cruz with machinery, which machinery, owing to the difficulties of communication in those trying days, did not reach its destination until the following year. This English syndicate's success was so indifferent that in 1848 they entered into liquidation, with a loss said to have reached the sum of $5,000,000.

"The local British colony, which has numbered as many as 600 souls, may be looked upon as the importation of the Taylor Co., and is still a force to-day in the encouragement of mining in the State of Hidalgo.

"I may say, in passing, that I fear you will not find much to interest you here in the mechanical line, and you may fail to add to your scientific attainments through an inspection of our machinery plants, because they have all been imported. In any case, having come, as you all have, from the greatest Republic, which is to play such an important part in the history of the future, you will not expect too much from us. We hope that the time is not far distant, however, when Mexico will cease to be under the necessity of bringing so much machinery from abroad. With such an influx of foreign money, we can anticipate the erection of extensive concerns to be devoted to the construction of all that we need. Mexico's resources are practically inexhaustible, and there is an immense field here for the remunerative investment of capital.

"Turning to Santa Gertrudis, there are indications of work having been done on this spot during the Spanish occupation, and the venture appears to have been abandoned at some period, owing to the excessive cost of deep mining. It is not known exactly, I believe, when the attention of the English was first attracted to this property, but it seems to have been transferred from one to another during many years until 1875, October 25th, on which date it was acquired by Messrs. William Stoneman and Christopher Ludlow, the former a worthy pioneer and authority on mining, and the latter still a deserving resident of Pachuca.

"These gentlemen, having insufficient means to continue their explorations and provide drainage facilities, decided eventually to form a small company among their friends, and many stories are told of offers of fortunes in stock made to and declined by them, their faith being at a very low ebb. In 1877 Señor José de Landero y Cos was induced to subscribe for two bars (a bar being $\frac{1}{24}$th), Captain Francis Rule and others also taking stock. Shortly after the formation of this company ore was discovered by accident whilst timbering, and the bars were soon quoted at $5000 each, after the total assessment per bar had only

amounted to $80. In 1878 dividends to the amount of $28,800 were paid. In 1879 a Cornish pump and steam hoist were installed on the new vertical shaft to the west, thus enabling the company to reach a depth of 240 meters. In 1890 a second Cornish pump was necessarily erected on another shaft to the east (the San Guillermo), for the purpose of lifting the water to the original pump. Up to 1883, if exception be made of the frequent and unfortunate changes of executive and management, everything went well. In that year Captain Francis Rule accepted the management, and, subsequently, was elected to the Board of Directors, with Señor Francisco Hernandez, Secretary of the State of Hidalgo, and Señor Francisco Rosete as associates; and they continued uninterruptedly in office until July of this year, when they resigned, and were succeeded by Messrs. José de Landero y Cos, Agustin Inurritegui and Manuel Algara, three gentlemen of vast experience and undoubted integrity.

"From 1878 to 1883 the Santa Gertrudis Co. paid in dividends the sum of $921,600, and from 1883 to 1886 only $158,400. Within this latter interval a cross-cut, at a depth of 200 meters, was driven south, and another lode was discovered; and this, forming a junction to the east with the old lode, made Santa Gertrudis the great mine she is to-day.

"The net profits distributed from 1886 to 1901 reached a total of $2,487,020,

A Mexican Six-in-Hand.

not including dividends to free shareholders. The company's records from their commencement show a

"Total production valued at	$33,637,024.14
"With a total expenditure of	24,570,893.36
"Thus leaving a net profit to the stockholders of .	$9,066,130.78

"We have on this property 3 main shafts and 15 levels, the 16th being now opened up at a depth of 430 meters at the bottom of the San Francisco shaft.

"It is intended that said San Francisco shaft shall, with its new machinery be the center of operations, the other engines being dispensed with. This installation has been put in at an enormous cost. I could enlarge very considerably on this data relating to Santa Gertrudis, but I know that your time is limited.

"As regards Mexico, I feel that there is a grand future before her, and we shall all watch her evolution with deep interest. As to her people, perhaps I should entrust the task of extolling them to one more capable and more impartial. As I have only received kindness from them, my esteem is profound. But I will say that the Mexicans, as a whole, are intelligent, loyal, sympathetic, courteous and hospitable; and the foreigner who conducts himself as a gentleman among

them, doing his duty and nothing more, is treated by them as one of themselves, and with every desirable consideration. I deprecate all charges against individuals and authorities from men who have suffered in Mexico through behavior entirely hostile and reprehensible. If this country, ladies and gentlemen, has not already taken her proper place among the greater nations, it is because of the internal dissensions of the past, which had retarded her progress and civilization. But be sure that the blood of her heroes has not been spilled in vain, and that, under the banner of such as the great statesman who wields her destiny to-day, General Díaz, her pre-eminence is assured. In agriculture, mining, industrial enterprises, railway construction, education and general refinement, our Mexican brethren are making rapid strides. Were this not the case, ladies and gentlemen, the Pan-American Congress would not have assembled on Mexican soil, neither would I have had the most distinguished honor of my life, that of addressing such a learned and representative assembly as the one now before me."

On the return to Pachuca, a visit was made to the Hacienda de Guadalupe, a silver-reduction works, employing the *patio* process. The crushers and Chilean mills, which prepare the ore for the *patio* amalgamation, are driven by electric power.

The evening of Friday was occupied with a session, at which two papers were read, as reported in the official *Proceedings*. To these papers, and especially to that of Sr. Ordoñez, reference may be had for further data concerning the mining of the Pachuca district. It may be added here, that, according to the list prepared by the Local Committee, the metallurgical works of Pachuca comprise four *haciendas*, namely, *Loreto* (100),* *Guadalupe* (80), *La Luz* (70), and *La Purisima* (40), employing the *patio;* one, *Del Progreso*, practicing the Boss system of pan-amalgamation; and two, *La Union* (90), and *Bartolome de Medina* (50), in which a modification of the Kroenke method is used.

On Saturday, November 16th, a small party of guests remained in Pachuca to visit the haciendas above named, and the new Bronson concentrating-works, erected by an American on the stream which receives the tailings from all the Pachuca reduction-works. The whole stream is pumped through this plant, and mercury, amalgam and heavy slimes are caught in riffles and upon canvas tables. Mr. Bronson expects to recover $300 per day in this manner from the final waste of the mills.

By far the larger portion of the guests spent this day in a memorable excursion to the mining district of *Real del Monte*. The usual multitude of carriages and saddle-horses provided for those who wished to ride conveyed them, by a fine road,

* The figures in parenthesis give the capacity in tons of ore daily.

some 12 miles to the mining camp. After viewing the mines (for an account of which see the paper of Sr. Ordoñez already cited), the party proceeded to a magnificent oak grove, which crowns the mountain. From the crest of the divide a magnificent prospect was obtained, including the snow-clad crater of

Loving-Cup Presented by the Members of the Party to Carlos F. de Landero.

Popocatepetl. The following account of this episode is taken from the *Engineering and Mining Journal* of Nov. 30th—a special number, devoted to the Mexican meeting, and reflecting much credit upon the editors, publishers and correspondents of that periodical:

"In this country the lower hills are barren of all forest growth, but at elevations of between 8000 and 9000 feet, one enters suddenly into areas heavily timbered with live oaks and other evergreens. At the border of one of these groves crowning a high divide, between two valleys, the citizens of Pachuca had constructed a temporary dining pavilion, capable of seating about 700 guests. Large out-of-door kitchens had been built of brick, and here a score or more of cooks prepared the Mexican dishes, for which the mountain air and exercise of the morning had furnished the proper appetites. The writer will not attempt either to name or describe the viands. They were truly Mexican both in name and character, but it was not necessary to know what they were in order to do them justice. They were washed down (lixiviated, so to speak) with tricolored pulque and other liquids. With the champagne came the usual speech-making, which was characterized by brevity and good feeling. Mr. Olcott's address, delivered, as usual, in Spanish, was full of appreciation of the hospitality and courtesies which had been showered upon the Institute. Toasts were drunk to the Mexican flag and to President Díaz, and the luncheon closed with three rousing American cheers for the hosts of Pachuca and Real del Monte. After the luncheon, dancing in the open air was indulged in for an hour or so, and at 5 o'clock the long cavalcade started down the mountain for Pachuca. The return trip was made in about one-fourth the time required for the ascent, and the city was reached in good time, for departure was set for 6 o'clock. It is not reflecting the least upon the entertainment at other points to say that the day at Real del Monte was the most enjoyable one yet experienced. At each stop new surprises awaited the excursionists ; and if it were possible to kill with kindness and hospitality, Mexico would be guilty. From all sides the welcoming hand was extended, from the highest officials to the lowest peon. At every town the streets were lined with rows of the poorer classes, who looked with curiosity and smiling faces at the visitors, who were, in turn, just as curious, and just as pleased."

To the foregoing account the Secretary adds, by request, the following description, furnished by one of the enthusiastic diners, of one of the delicious Mexican dishes served at the banquet.

"Lamb cooked as follows : The carcass, cut into large sections, is placed in sacks made of the fiber of the maguey plant. A large pit is dug in the ground; the bottom is covered with glowing coals, and these are overlaid in successive order with a light covering of soil, then a sack containing the meat, another light layer of soil, another of coals, and finally a high bank of earth. This method cooks the meat to a delicious tenderness."

An admirable institution at Pachuca is the Scientific Institute, a good modern school for the education of mining engineers, surveyors and assayers, which occupies the thoroughly renovated and reconstructed building of an old Franciscan monastery.

Saturday evening, the indefatigable Governor and Local Committee sped the parting guests with a final farewell at the railway-station.

Tula.

A number of the guests, leaving Pachuca early Saturday afternoon, and subsequently rejoining the special trains, went ahead by train to Tula, from which station they enjoyed a delightful walk to the famous Aztec ruins in its vicinity.

Loving-Cup Presented by Members of the Party to Carlos F. de Landero. (Reverse side.)

Guadalajara.

Sunday morning, November 17th, found the travelers among the great irrigated fields and prosperous *haciendas* of the fertile

semi-tropical Lerma valley and plain, the granary of Mexico. At the station of Castillo, a delegation from the Society of Engineers of Jalisco, headed by Vice-President Don Ignacio Guevara, boarded the train for a preliminary greeting.

Guadalajara, the second city in Mexico as to size (population 107,000) and capital of the rich State of Jalisco, was reached at 11 o'clock. After an address of welcome, delivered at the railway-station by Sr. Don José S. Schiaffino, a venerable member of the Society of Engineers, and a suitable response by President Olcott, the visitors were left free from public engagements for the rest of the day, which was, in fact, a welcome day of rest, after the fatiguing though delightful activities of the week. The magnificent cathedral, a few blocks from the station (with its famous Murillo Madonna), as well as the streets and market-place, were inspected with interest.

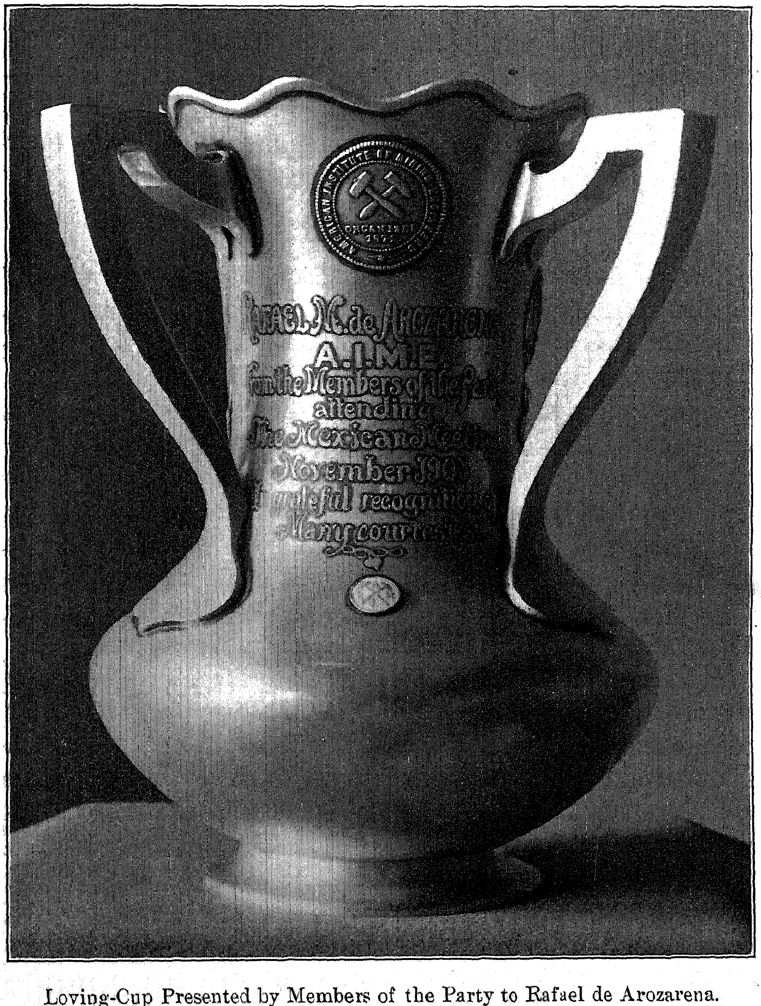
Monday morning, November 18th, the day's programme began with a car-ride along the *Hospicio* Avenue to the City Orphan Asylum. This remarkable institution covers a large block, and is divided into 23 *patios*, or courts, embellished with orange- and palm-trees, fountains, etc. It comprises schools of various kinds, including trade- and manual training schools, in which one of the interesting occupations is the making of the characteristic Mexican "drawn" lacework and embroidery. The institution is managed by the State, and has about 600 inmates, representing the poor of all ages.

After visits to the cathedral, government palace, and other features of the city, a trip was made by mule- and steam-cars to the picturesque Barranca de Oblatos, about 7 miles from the city. This is a cañon 1500 ft. deep, in the bottom of which are the municipal water-works. A Mexican breakfast, served in a casino on the brink of the precipice, was followed by national dances by the rancheros, accompanied with music from a large band. Sr. Don Ambrosio Ulloa, Secretary of the Society of Engineers of Jalisco, made a graceful address, to which President Olcott responded.

The following account of this locality is taken from the *Iron Age* of November 28, 1901:

"The Lerma river empties into Chapara lake to the southwest of Guadalajara, this lake, the largest in Mexico, being about 90 miles long by about 30 miles wide. Although there are no large towns, there live on its banks about 150,000 people. From this lake arises the Santiago river, which, after a drop of many

feet at the Salto Juanacatlan, the Mexican Niagara Falls, flows to the Pacific in what is practically a cañon, or 'barranca,' for over 100 miles. The depth of the cañon varies from 1000 to 1600 feet, and in some of its parts the walls are sheer on both shores. At the point visited the banks consist of a series of terraces of surpassing beauty. Looking down into the cañon, there is visible the lower portion of a canal and the power-house of an electrical station, which furnishes power for lighting and for textile and other mills and factories in Guadalajara.



Loving-Cup Presented by Members of the Party to Rafael de Arozarena.

The canal was built by three parties, and through subsequent events the supply has been divided into three parts, the owner of only one of them having thus far developed it partially. There is a head of 65 meters, and there is available in all about 10,000 horse-power. It is proposed soon to convert the present horse-car lines of Guadalajara into electric lines, and there is also a project on foot to utilize the power at the Salto Juanacatlan."

On the way home, a visit was made to the School of Arts, a fine building, not yet completed, containing a foundry, machine-shop, carpenter's shop, etc., for the instruction of boys. This institution is under the care of the clergy.

A visit was also made to the American Sanitarium, a branch of a similar institution at Battle Creek, Mich.

The festivities of the day were concluded with a grand evening concert, given on the plaza, by the celebrated bands of the 27th battalion and the State Guard, and a ceremonious farewell at the railway-station. Loaded with large quantities of the interesting Guadalajara pottery, purchased during their visit, the party left the hospitable city at 11 P.M.

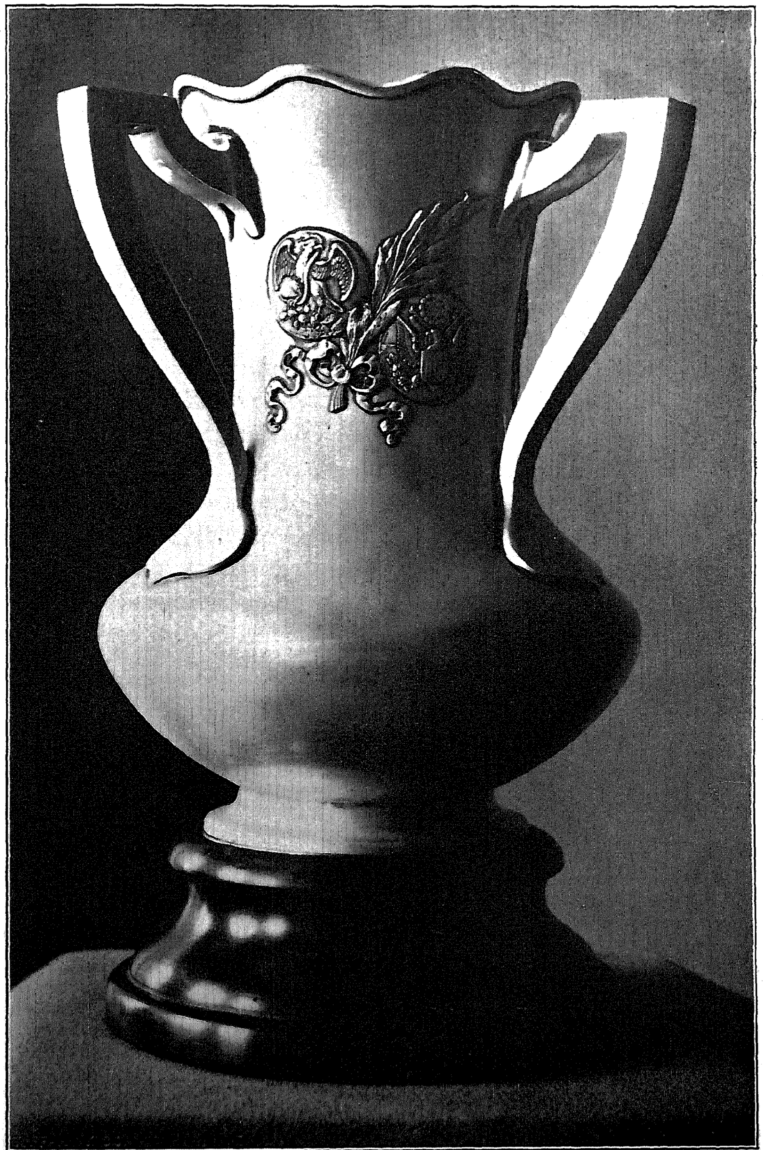
Guanajuato.

Early in the morning of Tuesday, November 19th, the trains reached Marfil, the railroad-station three miles from Guanajuato, where the Reception Committee, with the usual band, received the party, and escorted them to the town. The trip was made in mule-cars, through the narrow gulch lined with old *haciendas*, mine-dumps, etc., and the still narrower streets, running between one-story adobe and stone houses, to the commodious three-story building of the Guanajuato Club, which was the headquarters of the Institute during its two days' stay in this quaint, curious and interesting, as well as in many ways important, mining center. Here they were welcomed by many American and English, as well as Mexican, members.

The first professional visit was made to the reduction-works of the Guanajuato Cons. Mining and Milling Co., now under enlargement, which will increase the former 20 stamps to 60. The ore is pulverized, concentrated on Whilfley tables, and then amalgamated in pans. A walk of half a mile along the mine-railroad track led to the opening of the old mine, and another half-mile through an adit-tunnel, lighted by electricity, brought the party to the present underground workings, where the ore, broken about 80 ft. below the tunnel-level, was carried to that level in sacks on the backs of men, who ascended a very steep stone stairway. The miners were naked except for a small loin-cloth. It is reported that there is now in sight $5,000,000 worth of ore, to say nothing of vast quantities yet to be uncovered.

Lunch was served at the handsome building of the State

College. As one of the reporters remarks, "from the nature of this entertainment, it appeared that the fame of the previous



Loving-Cup Presented by Members of the Party to Rafael de Arozarena.
(Reverse side.)

ones had traveled ahead of the special trains, and the citizens of Guanajuato had determined to excel, if possible, the attempts

made at other towns." But the same authority adds that "it is not possible to make any comparisons!" A pleasant novelty, however, and a grateful reminiscence of home, was presented on this occasion in the circumstance that the menu was composed almost entirely of American dishes. After lunch, the interesting mineralogical and geological collections of the college were visited, and, still later, a trip was made by mule-cars to *La Presa*, where the narrow gulch is divided by dams into a series of lakes, surrounded by beautiful parks, the mountain-sides and narrow bottoms being occupied by the handsome houses and gardens of the wealthy residents of Guanajuato.

In the evening, the fine new Juarez theater and other State buildings were illuminated in honor of the visitors, and a ball, attended by the Governor and many of the Mexican citizens and ladies, was given at the Club, after which the party returned to spend the night upon the special trains at Marfil.

On Wednesday, November 20th, a memorable saddle-trip was made by the gentlemen of the party. Horses were furnished through the courtesy of the Governor, who ordered a troop of cavalry to report at the Cantador Park, dismount, and turn over their horses to the visitors. The ladies and others of the party meanwhile visited the old catacombs, the American hospital, and other points of interest.

The equestrian party visited the Esperanza reservoir (which has a stone dam 33 meters in height, and one of the finest in the world), and the *Valenciana*, *Cata*, *Mellado* and *Rayas* mines on the *Veta Madre*. (See descriptions below, and also the paper by Prof. W. P. Blake, separately published, entitled "Notes on the Mines and Minerals of Guanajuato, Mexico.")

Both companies of excursionists met at the State College for lunch, and subsequently visited the historical *Granaditas* building and the Flores *patio* reduction-works, where 40 *arrastres* were in operation.

From the souvenir-programme distributed by the Local Committee the following account is taken:

"This district has always had the reputation of being second to none of the mining centers of this Republic for its producing capacity of the precious metals. The City of Guanajuato has a population of 41,243 inhabitants, the greater number of which are exclusively dedicated to mining. It is situated in one of the gulches on the western slope of the Guanajuato Sierra. The first buildings date from the year 1554.

"The surrounding mining territory covers an area of 784 sq. kilom. between two parallel lines 28 kilom. in length, which run NW. to SE., the course of the 'Mother lode.' This lode is crossed in every direction by numerous mineralized ledges, the junction of which with the Mother lode increases its great width, thereby forming one of the largest and richest deposits in the Republic. Of this extensive mining ground but a small proportion has yet been explored.

"The ledges that traverse this region may be considered as the constituents of three, or rather four, different systems.

"1. The *Veta Madre* system forms the center of a group of which the remarkable lode that bears this name is the widest, and has been the most productive. It runs NW. and SE., dipping 45° SW. Several other veins run parallel to it, while others are known to come in contact with it from a distance of over 1500 m. in different directions, forming thereby this extensive system.

"2. The *La Luz* system, considered as second to that of the *Veta Madre*, is situated 4 kilom. SW. of the main system. It is formed by two different groups of veins that cross one another. One group runs NW.-SE., parallel to the *Veta Madre;* some of its veins dipping SE. and others NW., and converging towards the surface. The other group is formed of veins that slightly differ from the N.-S. direction, some dipping W. and others E. The crossings of the NW.-SE. with the N.-S. veins have coincided with the large *bonanzas* of this region.

"The first mine worked in the Guanajuato district was the *San Bernabe*, discovered in 1548 by pack-mule drivers traveling from Mexico City to Zacatecas. It is situated 13.5 kilom. NW. of this city, on the vein now called the *La Luz*, belonging to the N.-S. group, and dipping W. As an abundant producer of rich gold-ore this vein has always been remarkable.

"3. The *Monte de San Nicholas* system, comprising several veins, lies 4.5 kilom. SE. of the Mother lode, and parallel to it in course and dip. The veins of this system are noted for their abundant production of high-grade gold-ores.

"4. The *Sierra* system includes the *Santa Rosa*, *Fragua* and *Villalpando* veins, which slightly converge to the N., with a course similar to that of the Mother lode. Several dip SW., and others in a contrary direction; both converging towards the surface.

"The argentiferous minerals contained in the veins of this district are simple sulphides, sulpho-selenides, antimonial sulphurets and native silver. These occur plentifully in all the rich deposits found up to date. Chlorides and bromides occur very seldom. There is more or less gold in all the ores, and it is notable that all the veins to the SE., in the rhyolitic porphyry, carry high-grade gold-ores, containing generally free gold, but in exceptional cases selenides and tellurides, or gold contained in the iron pyrites.

"The deepest workings in the district are the *Valenciana* shaft on the Mother lode and the *Asuncion* shaft in the *La Luz* region. The former is sunk to a depth of 530 m., and the lowest workings of the mine are 1668 m. above sea-level. The latter is 419 m. deep, and at the lowest point attained 1870 m. above sea-level. In the *Sierra* region the depth of 2000 m. above sea-level has not yet been reached.

"For want of the necessary data, the production of gold and silver from the Guanajuato mines prior to 1701 cannot be stated with accuracy. Humboldt, in his *Political Essay*, attributes to them a very heavy production. According to coinage-statistics, the yield in the years mentioned below was as follows:

From 1701 to 1800, ...	$279,690,689
" 1800 " 1829, ...	85,775,642
" 1830 " 1887, ...	277,608,876
	$643,075,207

"The imperfect system of reduction employed until 1866 warrants the opinion that these represent only about 60 per cent. of the contents of the ore mined."

Returning at 4 P.M. to Marfil, the party left soon after.

Aguascalientes.

Early in the morning of Thursday, November 21st, the special trains arrived at Aguascalientes. Here the excursionists were welcomed by the Local Committee and conveyed to the State Palace, where they were received by Governor Sagreda, after which a visit was made to the smelting-plant of the American Smelting and Refining Co., the following notice of which is taken from the *Engineering and Mining Journal* of November 30th:

"Aguascalientes is a central point to which the smelting-ores from Parral, Chihuahua, Ameca, Pachuca and other mining districts in the Republic are sent for reduction. The works at present are undergoing extensive alterations under the supervision of Mr. Cyrus W. Robinson, chief engineer for the company. These alterations, which will cost about $650,000 in gold, will be finished about next June. In the meantime, no interruption to the operations of the plant has been caused. From 1100 to 1200 tons of copper and silver-lead ores and concentrates are being smelted daily. The product, which, of course, varies in quantity according to the contents of the ores treated, consists of blister-copper and base bullion (silver-lead), which are shipped to Perth Amboy, N. J., for refining. When the alterations are completed, the capacity of the plant will not only be largely increased, but many economies of operation will be effected, and a great saving made in the condensing of the furnace gases, which at present carry off a considerable value. The plant will then be a strictly up-to-date establishment, with electrical equipment throughout, and equal to anything of the kind in the United States. Even now it stands out in striking contrast to the mining methods employed in Mexico generally, where nearly all of the labor is performed by peons, and where mechanical installation is at a minimum."

Lunch was served in the mess-hall of the company's officials, and, returning to the city, many of the travelers availed themselves of the famous warm baths, supplied by the springs to which the town owes its name. A grand band-concert in the afternoon in the San Marcas garden, and another in the evening in the *Plaza de la Constitucion*, completed the day's experience, and at midnight the special trains proceeded on their way.

San Luis Potosí.

Friday morning, November 22d, the party was welcomed at San Luis Potosí by the Local Committee, with a military band.

The remainder of the day is well described in the following paragraphs, from the *Engineering News* of December 5, 1901:

"The Local Committee escorted us to street-cars, which took us to the Government Palace, where we shook hands with Señor Ingeniero Don Blas Escontria, Governor of the State of San Luis Potosí, and a distinguished engineer. He made us a speech in Spanish, which Mr. Olcott translated for our benefit, and then replied to it in Spanish. We were then taken back to the station, and thence by train to the smelting-works of the Compania Metallurgica Mexicana. This is a splendid works, thoroughly modern, turning out silver-lead bullion and copper matte, which are shipped to the United States for refining. It is owned by Americans, and is in charge of an American engineer, Mr. A. S. Dwight, who acted as chairman of the Local Committee. Besides the sampling works, the smelting and roasting furnaces and the machinery, there is in the works a plant for making tannin extract out of the bark of the wood which is used for fuel. The bark is ground and then leached in large vats, and the weak solution thus obtained is concentrated by boiling in a vacuum pan. The extract is exported for use in tanneries.

"The social features of our visit to the metallurgical works surpassed anything of the kind that we have yet experienced. Mr. Dwight has a commodious residence close by the works, with a large porch on the second story, looking out on a magnificent view with high mountains in the far distance, and in front of the house was a large and beautiful garden, in which were set tables shaded with awnings and decorated with flowers. All of this was at our disposal for a resting-place during our visit, and at 1 o'clock an excellent lunch in the American style was served by an efficient corps of waiters.

"At 2.30 P.M. the train carried us back to the town, and the party broke up into groups to visit different places of interest. Several of us visited the furniture-factory of Jorge Unna & Co., and the tobacco-factory of Señor D. Antonio Delgado Renteria. The furniture-factory is a remarkable place. Mr. Unna is a German, who began the business with six workmen only twelve years ago, but the works now occupies a whole square and employs 200 people. Furniture of the highest quality only is made, and it is all hand-made and hand-carved. The works includes an iron foundry and machine shop, a cabinet shop, including sawing and planing machines, a glass-grinding, polishing and silvering shop, weaving machines for weaving braids, a designing and drafting room, and storehouses where are kept in the most perfect order the thousands of things that are necessary to the production of the great variety of artistic furniture turned out by the establishment. The designs are made after a study of albums of engravings and photographs of the best European furniture, both old and new. There is nothing in the works to remind one of an American factory, where quantity and speed of production are the great essentials; it is all essentially German and Mexican.

"The tobacco-factory makes cigars by hand, and cigarettes both by hand and by machinery. A few American cigarette-machines are in use, but the style of cigarette preferred by the Mexicans is made by hand, and machinery has not been adapted for making it. In one room we saw over 400 girls, sitting in rows, each with a large wooden bowl containing the tobacco. The task of each was the rolling of 3200 cigarettes, which was accomplished in 7 or 8 hours, the wages paid being 60 or 70 cents, Mexican, per day. The clean and respectable appearance of these Mexican girls was most noticeable.

"In the evening there was a serenade by the bands of the 15th Infantry and of the Military Industrial School. It was held in the Plaza des Armas, a small park in front of the Palace. Seats were provided for our party, and the whole population of the city seemed to be present, walking around the park in two double rows, one of men, the other of women, or standing in crowds throughout the park and in the surrounding streets. It was especially noticed that the majority of the people wore American dress in all its varieties, only a minority wearing the Mexican sombrero and zerape. Shoes were also worn by nearly all, bare feet and sandals both being much more rare than we have seen in other places.

"At 10 o'clock a grand ball was given in the clubhouse of the *Sociedad Potosina*. The ball-room is one of the finest rooms we have seen in our travels. It is said to be a copy of the ball-room in the Winter Palace in St. Petersburg. The decorations and the general color-effect are exquisite. During the ball a supper was served in the French style, in 13 courses, with French wines. After the ball, the special street-cars returned us to the train; and we left for Tampico at 2 A.M."

Tampico.

Early in the morning of Saturday, November 23d, having passed through the San Ysidro valley in the night, the tourists found themselves at Cardenas, on the way to the port of Tampico. The following description is substantially taken from the *Iron Age* of December 5, 1901:

"Soon after, the train entered the great cañon of the Tamsopo, fringing its one wall in a series of curves and tunnels—a splendid piece of engineering. The steep slopes of the cañon are heavily wooded, the bare cliffs rising on every side. At the mouth of the cañon lie the tropical lowlands. A stop was made to view the charming upper pool of the *El Abra* falls; and towards evening a visit was made to the fantastic *Chov* cave. The train reached *La Barra*, beyond Tampico, in time to permit a stroll along the beach of the Gulf in the moonlight. Extensive jetties have been extended into the sea at the bar, about 6 miles from Tampico, permitting the entrance of ships drawing from 18 to 21 ft. of water.

"Having thus descended in one day from the plateau of Mexico to the tropics, many of the party were up at sunrise on Sunday for a plunge into the breakers, in spite of warnings of the risk of encountering sharks. Later in the day the journey was resumed.

"After the somewhat exciting descent of Saturday, a new experience awaited the party on the Monterrey and Mexican Gulf railway, which extends from Tampico to Monterrey, and beyond. This enterprise has had a checkered career, having been at one time in the control of Belgian capitalists. A few days before the Institute party reached Tampico, the road was transferred to the interests controlling the Mexican Central R. R. In running over a long-neglected roadbed, the heavy Pullman cars swayed ominously, and it was many hours after schedule-time that the trains steamed into the station of Monterrey, where two military bands had long awaited their arrival."

Monterrey.

This large town, the industrial center of northern Mexico, was reached on Monday, November 25th. The following description of the excursions and entertainments of that day and the day following, like the passage preceding, is substantially copied from the article in the *Iron Age* of December 5, 1901.

"In the afternoon the party visited the Monterrey plant of the American Smelting and Refining Company, known as Smelter No. 3, which confines its operations to the production of argentiferous base bullion, and the works of the Monterrey Smelting and Refining Company known as Smelter No. 2. The latter, which is controlled entirely by Mexican capital, is equipped not alone for lead smelting, but also for the desilverization of base bullion by a modification of the Parkes zinc process, and for the parting of dore bars by the Moebius process. To the majority of the engineers, however, the most interesting and almost startling development of Monterrey was the large steel plant which is now under construction there. The *Cia. Fundidora de Fierro y Acero de Monterrey, S. A.*, is a concern organized by Mexican and French capital, the principal interest being held by the estate of Patricio Milmo. It has a capital of $15,000,000 (Mexican), of which about 35 per cent has been called in. The layout is exceedingly fine, the consulting engineer being William White, Jr., of Pittsburg.

"In the evening the party attended a ball tendered by the Local Committee at the Juarez theater.

"Tuesday morning, November 26th, a special train carried the party for a visit to the *Diente* gorge, about 15 miles from the city. The mines are located high in the mountains, the tunnels opening at almost inaccessible points on the cliffs. The narrow valley which the railroad reaches is really only the shipping-station for two of the mines, the *Diente* and the *Zaragoza* mines. In the case of both there are very interesting installations of wire-rope tramways. The owners of the *Diente* mine, the Mexican Ore Company (an American enterprise), are building an incline. This concern owns also the *San Pedro* and *San Pablo* mines in the district, and employs about 3000 men. The ore is lead-carbonate and galena, carrying about 20 per cent. of lead, but only 3 to 12 ounces of silver, per ton.

"At noon the party assembled at luncheon in the handsomely decorated pavilion of the *Zaragoza* mine. After a welcome from the Governor of the State of Nuevo Leon, the party gave three rousing cheers for Carlos de Landero, of Mexico, a representative of the Institute, who was chiefly instrumental in perfecting the arrangements for the Mexican meeting."

A session was held in the evening, at which several papers were presented (see *Proceedings*); after which three military bands gave a concert in the *Plaza Zaragosa*, followed by a ball at the beautiful Monterrey Casino.

Las Esperanzas.

During the night, the trains proceeded to this place, which was reached November 28th, via Baroteran. The mines and

plant of the Mexican Coal and Coke Company, a description of which will be found in the paper of Mr. Edwin Ludlow, read at the Monterrey session, was here inspected.

Homeward Bound.

The journey back to Chicago, via New Orleans, presented no features of special professional interest, except the brief stay of Train No. 2 at Beaumont, Texas, for a hasty glance at the famous new oil-field, and the extraordinary run from New Orleans to Chicago, already mentioned on a former page of this account.

The arrival of the excursion-trains at Chicago on Saturday, November 30th, practically concluded a successful and interesting journey, memorable in the annals of the Institute.

Acknowledgments and Presentations.

Under this head, the following particulars were deemed worthy of record:

1. In recognition of the cordial interest exhibited by Gen. Porfirio Díaz, President of the Republic of Mexico, in the meeting of the Institute, and the effective aid contributed by the various executive departments of the government under his direction, towards the professional profit, as well as the social enjoyment thereof, a complete set of the thirty volumes of the *Transactions*, handsomely bound, was presented to him, by authority of the Council, in the name of the Institute, and acknowledged by him in a personal letter to President Olcott, dated Mexico, Jan. 11, 1902, of which the following is a translation:

"MEXICO, Jan. 11, 1902.

"ESTEEMED SIR:

"Referring to your communication of the 30th of December last, I hasten to express my hearty thanks for the courteous gift of the valuable Transactions of the American Institute of Mining Engineers, in thirty volumes. I have placed these important books in the National Library of Engineers, as their most appropriate repository.

"Your most obedient servant,

"PORFIRIO DÍAZ."

2. Silver vases have been presented, in the name of the Institute excursion party, to Señors Carlos F. de Landero and Rafael M. de Arozarena, in recognition of their pre-eminent

labors in the promotion of the Mexican meeting, and in the reception of the visiting members of the Institute.* These vases, shown in the accompanying illustrations, were forwarded through the U. S. Department of State, and courteously allowed by the Mexican government to pass the international boundary free of all customs dues.

"PACHUCA, May 14, 1902.

"DR. ROSSITER W. RAYMOND, Secretary, American Institute of Mining Engineers, New York City.

"*My Dear Sir:*

"I have the honor to acknowledge receipt of your esteemed communication of last April and of the magnificent silver loving-cup, forwarded by your office, through the United States Embassy in the City of Mexico, and presented to me in the name of the members and guests of the Institute who attended the recent Mexican meeting.

"I beg you be so kind as to interpret my feelings, in your own high and dignified style, assuring all and every one of the friends who have honored me with this symbol of their esteem, how highly I do appreciate their friendly token, and how heartily do I thank them. May this handsome gift, whereon your ablest artificers have so perfectly engraved the sacred emblems of our two countries, be for the givers and the receiver a symbol of hope that peace and friendship be abiding and everlasting between their and his country!

"Trusting to have the honor and pleasure to meet you personally in the near future, possibly in the next coming meeting of our Institute, I remain,

"My dear Sir,

"Yours very sincerely and respectfully,

"C. F. DE LANDERO,

"Vice-Pres. A. I. M. E."

"MAY 14, 1902.

"MR. R. W. RAYMOND, Secretary American Institute of Mining Engineers, New York City.

"*My Dear Sir:*

"Your kind favor dated April received, as well as the beautiful loving-cup you had been instructed to send me by the members and guests of the party who attended our Mexican Meeting.

"I know not with what words I can express to you my feelings at this moment; to say I feel honored and delighted at this proof of friendship, that I will always cherish it for what it signifies, that all the good people who sent it have and ever will have a warm place in my heart, that I truly learned to love and esteem them while we were together,—to say all this and more, would still be saying nothing near to what I feel.

"Dear Mr. Raymond, will you finish your kind mission with a favor for me. Tell them, my friends, one and all, that all they feel, I feel and more; that I was glad the day I met them and sad the day we parted.

"Sincerely yours,

"R. M. DE AROZARENA."

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* These gentlemen met the Institute party at the border of Mexico, and remained with it, as perpetual guides and counsellors, throughout its entire sojourn within the boundaries of the Republic.

3. During the evening of Nov. 29th, on the run from New Orleans to Chicago, similar pleasant and almost simultaneous incidents occurred on each of the two trains.

Upon No. 1, the members of the party quietly gathered in the Observation end of the car "Pacific," and sent a delegation to Mr. Dwight, who was in his state-room; upon whose appearance, two handsome pieces of Creole silver were presented to him in a graceful and humorous speech by Prof. George E. Ladd, as an expression of appreciation of his efforts in looking after the safety and comfort of the party.

Upon No. 2, at the dinner-hour, when all were gathered in the dining-car, Mr. W. E. C. Eustis made a presentation, on behalf of the passengers in this train, of two handsome pieces of Creole silver to Mr. Edward W. Parker, who, as previously remarked, had discharged the laborious work of caring for the safety and comfort of that party.

In both cases the recipients were completely taken by surprise, and could not attempt to reply, or even to express their appreciation, otherwise than by their obvious embarrassment and equally obvious pleasure.

4. About five hundred handsomely engraved official acknowledgments have been transmitted to the various officials, companies and citizens of Mexico, whose hearty co-operation so greatly contributed to the success of the meeting and of the excursions connected therewith.

P A P E R S.

A Synopsis of the Mining Laws of Mexico.

BY RICHARD E. CHISM, M.E., PH.D.. MEXICO CITY.

(Presented at the Mexican Meeting, November, 1901, and Copyrighted by the Institute.)

CONTENTS.

NOTE.—The following abbreviations are used in reference to the laws, etc., cited in this Synopsis:

C. FOM., Circular of the Ministry of *Fomento* (Mining).

C. HDA., Circular of the Treasury Department.

C. ADM. DEL TIMBRE, Circular of the General Administration of the Stamp Tax.

L. MIN, Mining Law of June 4, 1892.

L. IMP., Mining Tax Law of June 6, 1892.

R. L. MIN., Regulations of the Mining Law, June 25, 1892.

R. L. IMP., Regulations of the Mining Tax Law, June 30, 1892.

L. MET. PREC., Law as to Taxes and Duties on Precious Metals of March 27, 1897.

R. L. MET. PREC., Regulations of said Law of March 27, 1897.

TAR., Tariff of said Law.

INTRODUCTION.

IN 1885 I presented at the Chattanooga meeting of the Institute a Digest of the Mining Code of Mexico in force at that time.* Since that time the law has been radically altered, and I have thought that it would be of interest to the Institute to have in its *Transactions* a synopsis of it as it now stands.

In order to reduce the volume of this synopsis, which is at best very extended, I am compelled to omit many details, for which I must refer the reader to my *Encyclopedia of the Mining Law of Mexico;* but all the fundamental part of the law has been carefully retained.

The pursuit of mining in Mexico under the Spanish dominion was governed by disconnected decrees and ordinances until the year 1584, when were formed what are called the *Ordenanzas del Nuevo Cuaderno*, under the Government of Philip II.

These laws governed until January 15, 1784, when the famous "Ordinances of Mining," which had been enacted by the King of Spain in May of 1783, came into force in New Spain.

After the accomplishment of the independence of Mexico, the Spanish Ordinances remained in force, with very few changes.

In 1857 a new Constitution was adopted in Mexico, which did not delegate the power of mining legislation to the General Government, and hence left the several States free to enact their own laws.

However, nearly all of the States continued to use the Spanish mining legislation. Only two States, Durango and Hidalgo, adopted mining codes of their own.

The changes of governmental methods, and of mining and metallurgical systems, made the old legislation so difficult in its applications to the modern form of mining industry that it was resolved to adopt another organization, which should be general in its character and uniform for the whole Republic.

In 1883 a Constitutional amendment was adopted conferring upon the General Government of Mexico the power to legislate upon mining matters, and in November, 1884, a new Mining

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* *Trans.*, xiv., 34.

Code, with accessory legislation, was adopted, and put in force from January 1, 1885. By this new Code the Spanish Ordinances of 1783, the succeeding colonial legislation, and subsequent Federal and State laws upon mining, were utterly abolished, even those parts which were not contrary to the provisions of the new Code. (Code, Art. 218.)

This new code was the one of which I made the Digest which appears in our *Transactions*, as quoted above. Its principles were, in many respects, a great improvement upon the vague legislation of the old *Ordenanzas*, and were especially beneficial because they did away with the conflicting legislation of the several States.

However, when the monetary crisis arising from the fall of silver began to be severely felt in this Republic, the necessity of still more liberal mining laws became apparent, and resulted in the promulgation, June 6, 1892, of the present law, with its accompanying and subsidiary laws and regulations.

The old Spanish laws and the Mining Code of 1884 were based upon a working tenure of mining property, under conditions hard to fulfill and fruitful of litigation.

The law of 1892, based on principles entirely modern and liberal, gives the miner the property of his mines in an irrevocable, perpetual and secure form through the payment of a yearly tax, with full liberty as to methods of work and amount of work to be done. This law is one of the most illustrious monuments to the executive ability of General Diaz and his cabinet that could possibly be desired. Its results were immediate and conspicuous. Immense mining and smelting establishments have sprung up, the cost of the production of silver has been greatly reduced, and the gold-product of the Republic has increased very largely. Foreign capital has been liberally invested, and is still flowing in an increasing stream into the Republic, which, in a few years, will undoubtedly be the largest producing mining country in the world. The wise and liberal law of 1892 saved Mexico from national bankruptcy, and started it upon a career of prosperity which is entirely without precedent, except, perhaps, in the development of the South African goldfields.

The following table, taken from a government publication, is a convincing demonstration of the influence of wise legisla-

tion upon the progress and growth of the mining industry. It refers to the silver-product of Mexico only; but the figures for gold would show an even more flattering increase:

	Quinquennial of Fiscal Years.	Silver. Exportation of Ores, Bullion, Mexican Coin.	Annual Average.	Annual Average Increase.
Legislation of the States............	From 1880-81 to 1884-85	$126,771,390	$25,354,278	....
Unification of the Legislation in the Republic. Mining Code of 1884..............	From 1885-86 to 1889-90	167,993,780	33,598,756	$ 8,244,478
Law of 1892—In force..............	From 1893-94 to 1897-98	267,417,591	53,483,518	19,884,762

The fundamental part of the Mining Law of Mexico is contained in a little pamphlet of one hundred and nine pages, which can be obtained at the *Fomento* Department free of charge.

The contents of this pamphlet comprise the Mining Law of June 4, 1892, with its Regulations, and the Mining Tax Law of June 6, 1892 (also with its Regulations), and a few Circulars and subsidiary Laws.

These Laws are, in effect, the fundamental portion of the Mexican Mining Code at present in force; but the whole body of legislation which affects the rights of miners, and especially foreign miners, in this country is very much greater.

We have:

The Mining Law of June 4, 1892.

The Regulations thereto.

Thirty-four Explanatory Circulars, with Rulings of the Fomento Department.

Law of October 31, 1892.

Decree of December 31, 1892.

Law of June 4, 1894.

Law of December 13, 1897.

Law of June 3, 1898.

The Mining Tax Law of June 6, 1892.

The Regulations thereto.

Thirty-nine Circulars, with Rulings of the Treasury and Revenue Stamp Department.

Law of Taxes and Duties upon Precious Metals of March 27, 1897.

Regulations of said Law.

Tariff of said Law.

Besides which, many references are made to:

The Civil Code of the Federal District of Mexico.

The Code of Civil Proceedings of the same.

The Code of Commerce of the Mexican Republic.

The Foreign Law of 1856.

The Foreign Law of 1886, and

The Federal Constitution of Mexico.

In the present synopsis, the more important of the above laws have been carefully digested, and their provisions have been arranged in as orderly a manner as possible under the seventeen different heads, or sections, into which I have divided the subject as shown in the table of contents prefixed to this paper.

I. Mineral Substances.

The Mining Law of Mexico divides all mineral substances into two classes.

The first class contains such substances as may not be worked without a previous concession; and the second class, such substances as belong to the owner of the soil and may be worked without a concession.

1. The substances for the exploitation of which it is indispensable, in every case, to obtain a proper mining concession are the following:

A. Gold, platinum, silver, mercury, iron (except bog-ore, alluvial ore and ochres mined for coloring material), lead, copper, tin (except placer tin), zinc, antimony, nickel, cobalt, manganese, bismuth and arsenic, whether all these substances are found in the native state or mineralized.

B. Precious stones, rock salt and sulphur. (L. min., Art. 3.)

2. The substances which the owner of the soil where they are found in place may exploit freely, and without the necessity of a special concession in any case, are the following:

A. Mineral oils and mineral waters; the country-rock, which is to be used either for itself directly or as raw material for ornamentation and construction; the materials of the soil, as earth, sand and clays of all kinds.

B. In general, all other substances not before excepted. (L. min., Art. 4.)

II. The Exploitation of Mineral Substances.

The exploitation of mineral substances, whether those that are subject to concession or those that belong to the owner of the soil where they may be found, is subject to all the regulations that may be established for police and security.* After said regulations have been complied with, the miners shall enjoy the most complete liberty of industrial action,—liberty to work in the manner which may suit them best,—with activity, more slowly, or suspending their labors for a greater or less time. They may employ in their workings any number of workmen they may choose and at the point which they may believe to be most appropriate, and they may follow the systems which they may find most convenient for their private interest for removal, extraction, drainage and ventilation.

Notwithstanding, the mine-owners stand responsible for any accidents that may occur in the mines through bad working, and must pay the damages and losses that may be occasioned to other proprietors by lack of drainage or by any other circumstance that may injure the interests of other parties. (L. min., Art. 23.)

The exploitation of mine-products shall be strictly confined within the respective boundaries; and these boundaries can only be passed when the ground is free, and a previous concession of amplification has been obtained.

In order to enter any other person's claims it is absolutely necessary to have the consent of the owner, except in the case of a legally established servitude. (L. min., Art. 8.)

No exploitation of the substances which are subject to concessions shall be permitted in mines or placers, whether by open cut or subterranean workings, unless protected by a duly registered legal title. (R. L. min., Art. 43.)

Whenever it becomes necessary to open any drainage-tunnel in a given locality, the execution thereof shall be carried into effect according to a private contract between the interested parties. See Sect. XIII., of this Synopsis.

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* No such regulations have as yet been established (October, 1901).

III. Mining Property and Mining Claims.

Mining property legally acquired is irrevocable and perpetual as long as the Federal tax upon property is paid. (L. min., Art. 5.)

The primordial title-deed of all mining property acquired according to the laws now in force is that which is made out by the Ministry of Fomento by virtue of the powers conferred by said laws. (L. min., Art. 6.)

Mining property, except in case of placers or superficial deposits, is understood to include only the underground mineral right, and not the surface.

The owner of the mine must come to an agreement with the surface-owners for such part of the surface as he may need to acquire for mining purposes, as below.

The surface continues under the ownership of its proprietor, except in such part thereof as the miner needs to occupy in certain cases and conditions. (L. min., Art. 7.)

The water which is raised to the surface by virtue of the subterranean workings of mines belongs to the owner of the latter. The provisions of the common laws must be observed as far as relates to the rights of the owners of the lands over which said waters take their course. (L. min., Art. 9.)

Whenever the owner of any mine shall transfer the same, he must give notice thereof, in writing, to the Principal Local Administration of the Revenue Stamp Tax, through the corresponding subordinate office or agency.

Said Principal Administration shall give account thereof to the Secretary of the Treasury, to be duly noted in the register. (L. imp., Art. 8, and R. L. imp., Art. 27.)

The same notice must be given in the case that any person or company does not desire to continue in possession of any mine or mines which may have been acquired. (L. imp., Art. 8, and R. L. imp., Art. 27.)

The default of payment of the Federal tax constitutes at present the only cause of the loss of mining property, without any recourse.

In this case the mining property remains free from all encumbrance, and may be conceded to the first applicant. (L. min., Art. 29, and L. imp., Art. 6.)

Mining property is classed as real estate,* but mining stock is personal property.

The unit of a concession, which is a mining claim (*pertenencia*), is a solid of indefinite profundity. It is limited on the exterior by that part of the surface of the ground which serves as the projection of a horizontal square of one hundred meters on each side, and on the interior by the corresponding four vertical planes.

The *pertenencia* is indivisible in all contracts made as to mining concessions, and which affect the ownership of the same. (L. min., Art. 14.)

A fractional part of a claim cannot be the subject of a mining concession, unless it is found between other claims already conceded. (L. min., Art. 15.)

Those mines which may have been at work, or legally protected from the necessity of being worked, at the time when the Mining Law of June 4, 1892, commenced to be in force, shall preserve their claims with such measurements as they may have, if the owners so desire it, even though said measurements should be different from the new measurements now established. (L. min., Art. 4, transitory.)

Mining concessions may include, whenever there is sufficient free ground, whatever number of claims may be applied for, without regard to the number of applicants—whether one only or several—whether they constitute a company or not; and as many claims may be acquired as may be desired. (L. min., Art. 15, and C. Fom., July 1, 1892.)

The marking off and measurement of the claims on the ground does not imply any right to the occupation of the latter, and only serves to show the boundaries of the mining concession.

The applicant should thoroughly understand that he must agree with the owner of the land for the acquisition, whenever he may so wish, of such a part of the surface as he may need to occupy for the dependencies of his mining works, or of the whole of the surface marked off into claims (in the case of placers or superficial deposits).

If this acquisition cannot be made by mutual agreement

* By inference and precedent only; the law does not say so expressly.

with the owner, it may be effected by expropriation, through the appropriate judicial decision. (R. L. min., Art. 40. See *Expropriation*, Sect. XII. of this Synopsis.)

Applications for mining concessions in which interrupted (separated) claims are asked for are admitted whenever said claims are all in the same municipality and on the same mineral deposit; but in case the claims are in different municipalities or on different mineral deposits, separate applications must be presented with reference to each claim or group of claims in each separate mineral deposit or municipality. (C. Fom., October 31, 1899.)

IV. Prospecting for Minerals.

Any inhabitant of the Republic may undertake exploration work on public lands by giving notice thereof, in duplicate, to the local Mining Agent, in which notice the boundaries of the zone of exploration shall be accurately described.

The Agent shall return one duplicate notice to the explorer, after endorsing thereon the day and the hour of the presentation thereof, and shall notify the explorer that in case of making excavations there they shall not exceed ten meters of extension, either in length or in width. (L. min., Art. 13, and R. L. min., Art. 10.)

In those localities of the Republic which are not comprehended within the district assigned to any Mining Agent, the notices and vouchers for prospecting permits shall be presented to the local postmaster, who, in this case only, may receive said documents, and shall note on them the day and hour of presentation; and, besides, he shall give immediate notice to the Ministry of Fomento by mail, and by telegraph, if there is one. (R. L. min., Arts. 48 and 49.)

Upon lands belonging to private owners, prospecting can only be done by the permission of the owner or of his representative.* These persons, if they consent, must give to the prospector a proper voucher, with an indication of the boundaries of the lands where the prospecting is to be done. This voucher is to be presented to the Mining Agent, so that he may take

* Prospecting on private lands can only be done by permission of the owner; but soliciting a mining concession (denouncing a mine) on such lands does not seem to need any permission.

note thereof and return it to the prospector, after having noted thereon the day and hour of the presentation. (L. min., Art. 13, and R. L. min., Art. 11.)

If the necessary permission cannot be obtained from the owner or his representative, the prospector may apply for it to the local Mining Agent, offering a bond for the damages and losses that may be caused.

The application shall be on view for the owner of the land for the term of fifteen days, and he shall be notified that unless he puts in an objection he will be held to be a consenting party thereto.

When the above term has expired the Mining Agent shall give the proper decision, and, if necessary in any case, shall fix the amount of the bond after a careful estimate of the damages which truly and positively may be caused to the owner of the land, so that the bond may not be excessive.

When the bond has been drawn up the Mining Agent shall give to the prospector a proper voucher, with a description of the boundaries of the zone of exploration. (L. min., Art. 13; R. L. min., Art. 12; and C. Fom. of July 1, 1892.)

During the peremptory term of three months, counted from the date of the notice, of the permit, or of the administrative decision just referred to, the Mining Agent shall admit for the prospecting zone, and within the limits thereof, only such applications for a concession as may be presented by the prospector himself. (L. min., Art. 13, and R. L. min., Art. 13.)

In those cases where the Mining Agent may receive an expert report, under the responsibility of its author, in which the existence of subterranean gold-placers is indicated, the term or exploration may be lengthened up to one year. The rest of the proceedings shall be the same as for other prospecting permits, except that the shafts to be opened for prospecting may be as deep as may be necessary. (Law of November 13, 1899, Art. 1.)

The lengthening of the term of exploration for subterranean gold-placers is not to prevent the admission of applications for mining concessions, according to the laws in force, within the limits of the zone of exploration, to exploit deposits of any other minerals. (Law of November 13, 1899, Art. 2.)

The Mining Agent will be careful to publish, on his Bulletin

Board, a copy of the prospecting permit, notice or administrative decision, and must indicate, at the end of the respective copy, the exact dates on which the exploration should commence and terminate. (Law of December 14, 1897, Art. 2.)

When the peremptory term above noted has expired, no new prospecting permits shall be admitted to registry for the land explored, nor shall any prospecting notice be admitted with respect to the same ground, until after the expiration of six months, during which time the ground in question shall remain entirely free for applications for mining claims situated therein.

Within mining camps, where there are properties in possession, prospecting shall only be done on ground which is at least 200 meters from the boundaries of the claims or in abandoned mines.

In every case the prospector must clearly and precisely designate the situation and boundaries of his ground. (Law of December 14, 1897, Art. 1.)

Inside of private edifices and their dependencies, prospecting can only be done by permission of the owner.

Prospecting is not permitted near the nucleus of any town, or at a distance of less than fifty meters from the exterior lines of public and private residences and their dependencies. The same distance shall be observed with respect to any other public work or construction, but may be reduced to thirty meters from the exterior lines of common roads, railroads and canals.

As far as relates to fortified points, the minimum distance at which mining exploration can be carried on shall be one kilometer, starting from the exterior line of the works. (L. min., Art. 13, and R. L. min., Art. 14.)

According to the General Custom House Ordinances, Art. 452, such persons as may arrive from foreign parts to prospect for lands or mines, and who bring with them wagons, carriages, tools or instruments for prospecting, and who may solicit permission to enter the country therewith, may obtain the same from the Secretary of the Treasury, at his discretion. Such parties must give a bond, to the satisfaction of the local Custom House Administrator, to cover the amount of duties that may be determined at the time of arrival, and which must be paid

if the re-exportation of the goods is not made within the time fixed by the Treasury Department.

V. The Ministries of Fomento and Hacienda.

This first is generally called, in Spanish, "*Secretaria de Fomento.*" *Fomento* means "encouragement" in English, as nearly as it can be translated. Some later translators call it the "Department of Public Promotion," but there is no justification for using the word "Public," although the word "Promotion" is a passably fair translation of *Fomento.*

The Ministry of *Hacienda* corresponds to the Treasury Department in the United States. *Hacienda,* in this connection, means everything relating to public revenue and expenditure; in a more restricted way, it means the wealth of any individual; specifically, a plantation or farm.

The mining industry in Mexico is by law dependent upon the Ministry of Fomento. Said Ministry, as a branch of the powers vested in the Executive of the Union, may decree such measures as it may judge proper for increasing the prosperity of the mining industry, and shall watch over the fulfillment of the laws relative thereto, by means of the engineer inspectors of mines. (L. min., Art. 30.)

The said Ministry must pronounce on every docket of a mining concession the final decision corresponding thereto, and must issue the primordial title-deeds of mining property.

The said Ministry should publish every six months, in the *Diario Oficial* of the Federation, a list of the title-deeds which have been issued during said period. (L. min., Art. 6, and R. L. min., Arts. 16 and 50.)

Every time that the Ministry of Fomento issues a title-deed, a detailed account of the concession to which said title refers must be sent to the Secretary of the Treasury. (R. L. min., Art. 37.)

The immediate control of mining affairs in the Ministry of Fomento is committed to Section Third, which is, in fact, a Central Mining Office.

The Secretary of the Treasury, in its mining branch, has charge of the collection of the revenue stamp tax, of the annual mining tax, the coinage tax, the assay fees, etc., and of the exportation of the precious metals.

The Treasury Department may, whenever it shall consider it equitable and convenient to do so, modify the rule by which the annual mining tax is to be paid in the local Principal or Subordinate Administration of the Revenue Stamp Tax.

NOTE.—Mining taxes are frequently allowed to be paid in Mexico City, or in some other central locality, when it is not convenient to pay them in the district where the mine is located.

In such a case the Treasury will give notice thereof to the General Administration of the Revenue Stamp Tax, so that this office may communicate the same to the principal local stamp tax office where the mine is situated. (R. L. imp., Art. 20.)

The Treasury Department may grant a special concession to metallurgical companies to have their products assayed, and the taxes thereon liquidated, in their own establishments. (R. L. met. prec., Art. 1.)

The Treasury shall determine the compensation of public officers who sell stamps. (R. L. met. prec., Art. 1.)

The Treasury shall designate certain government offices, banks or commercial houses on which drafts may be drawn to pay for bullion purchased by the Treasury for coinage purposes.

Also, the Treasury shall fix the term in which said drafts shall be payable. (R. L. met. prec., Art. 20.)

The Treasury may fix the minimum value per ton which is to serve as the basis for drawing up bonds for the exportation of precious metals and substances containing them. (R. L. met. prec., Art. 35.)

The Treasury may make special regulations for the transportation of metals and minerals within the zones of twenty kilometers along the coast and the frontiers.

The Treasury may modify or condone any administrative penalties. (R. L. met. prec., Art. 34.)

VI. Mining Agents.

The primary authority of the Executive, represented by the Ministry of Fomento, is delegated to certain officials called *Agentes de Mineria*, or Mining Agents.

The Mining Law prescribes that the Secretary of Fomento shall appoint in any mining districts where, in his judgment, it may be necessary, special Agents dependent on his Depart-

ment. These Agents shall receive and put through the proper course all applications for mining property and surplus ground that may be presented to them, and shall exercise such other functions as may be designated for them in the law and regulations. (L. min., Art. 16, and R. L. min., Art. 1.)

An Agent of the Ministry of Fomento must be a Mexican citizen in full possession of his rights, and he must not be exercising any office of authority in the State or Territory where he belongs, nor in the Federal District. (R. L. min., Art. 3.)

For the legal impediments of the Mining Agent, see page 18 of this Synopsis.

At the time of appointing each Agent, the circumscription or the limits within which he is to exercise his office are to be designated, and the first boundaries, as well as any subsequent modifications of the same, shall be published in the *Diario Oficial* (official daily newspaper) of the Federation. (R. L. min., Art. 7.)

For each Agent who may be appointed in any mining district, there shall also be appointed such substitutes as may be required according to the amount of business in the district in question. Said substitutes must have the same qualifications as the Agents, and shall be the substitutes for the Agents in all temporary or permanent absences that may occur, as well as when, through legal impediment, the Agent is unable to act in any particular case; and for any of these cases they shall be previously summoned by the proper Agent. (R. L. min., Art. 4.)

The Agents, to exercise their office, should have a patent (*despacho*), with a revenue stamp of ten dollars. When they forward this amount they must also remit three dollars and twenty cents for the signatures and formalities of the patent. (C. Fom. of August 29, 1892; but this has been abolished by a recent enactment.)

Whenever any Agent wishes to absent himself from his place of residence for less than eight days, he may do so if he previously notify his substitute to act.

The substitutes do not need a patent; for the discharge of their office, simply the appointment conferred upon them shall be sufficient. (C. Fom., November 28, 1892.)

If the time of absence is to be longer than eight days, permission should be previously obtained from the Ministry of Fomento, and the cause of the absence and its duration should be noted, so that the Ministry may resolve upon the proper course. (C. Fom. of November 20, 1892.)

In case of death, or of serious illness which prevents the proprietary Agent from summoning his substitute, the latter may proceed to exercise the functions of the Agent; but he shall immediately advise the Department of Fomento thereof by mail, and also by telegraph, if the latter exists. (R. L. min., Art. 6.)

The functions of the Agents are administrative only, and are perfectly defined by the existing regulations as to mining. (C. Fom. of July 1, 1892.)

In case of doubt about the application of the law or its regulations, the Agents must consult with the Ministry of Fomento. (R. L. min., Art. 1.)

Agents have no right to accept more than the fee fixed by the proper Fee Bill, and they must consult the Ministry of Fomento with respect to the amount of their fees in any case not provided for in the Fee Bill. (R. L. min., Art. 8.) See *Honorarios.*

The books kept by the Agents do not need other authorization than that of the Ministry of Fomento. (C. Fom., August 1, 1892.)

The duties or obligations of the Mining Agents are:

1. To make known to the public the place in which they attend to mining business and the hours they devote daily to said business, which business must not be interrupted except on Sundays and national holidays. (R. L. min., Art. 7.)

2. To give course to applications for mining concessions in the manner to be described under the head of Acquirement of a Mining Concession, Sect. VIII. of this Synopsis.

3. To give course in the same way to the prospecting permits as is laid down under Prospecting, Sect. IV. of this Synopsis.

4. To proceed in cases of withdrawal (*desistimiento*), amplification (*amplificacion*), reduction (*reduccion*), or correction (*rectificacion*) of claims, according to the rules laid down under Sect. IX. of this Synopsis.

5. To report to the Ministry of Fomento any information required of him.

Agents are expressly prohibited from receiving and keeping on hand moneys intended for the payment of the annual mining tax. (C. Fom., April 12, 1892.)

The Agents are responsible for the errors or omissions in the dockets (*expedientes*), if said errors or omissions are imputable to them. (L. min., Art. 19, and R. L. min., Art. 31.)

Impediments.—A Mining Agent shall be deemed necessarily disqualified to act officially in the following cases:

1. In matters where he has an interest, direct or indirect.

2. In cases in which are interested any of his blood relatives in direct line, without limitation of degrees, his collateral relatives to and including the fourth degree, or his relatives by marriage to and including the second degree.

3. Whenever the Mining Agent or his relatives, as set forth above, have a lawsuit pending of a like nature to the one in question.

4. Whenever there exist between the Mining Agent and any of the parties in interest intimate relations proceeding from some civil or religious function, sanctioned and respected by custom.

5. Whenever the Mining Agent is an actual partner, tenant or employee of some one of the parties in interest.

6. Whenever the Mining Agent has been tutor or guardian of one of the interested parties, or is actually administrator of the property of such person.

7. Whenever the Mining Agent is heir, legatee or beneficiary of one of the parties in interest.

8. Whenever the Mining Agent or his wife or his children may be debtors or bondsmen of any of the interested parties.

9. Whenever the Mining Agent has been lawyer, attorney, expert or witness in the matter in question.

10. Whenever the Mining Agent is related by blood or marriage to the attorney of any of the interested parties in the degrees expressed in Paragraph 2. (R. L. Min., Art. 5, and Code of Commerce, Art. 1132, Sects. I. to IX., and XII.*)

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* These are the articles of the Code of Commerce relating to the impediments (disqualifications) of Judges of First Instance.

For the authority of the substitute, in case of the death, etc., of the Mining Agent, see p. 17 of this Synopsis.

Honorarios [Fees].—The Mining Agents of the Ministry of Fomento are authorized to charge fees according to the regular Fee Bill. (L. min., Art. 16.)

This Fee Bill is as follows:

1. For endorsing proprietors' prospecting permits or notices and registry of the same, one dollar (*peso*).

2. For the procedure and issuing of the prospecting permit issued by the Mining Agent when the proprietor refuses consent, two dollars.

3. For the registry of each application for a mining concession, or amplification and rectification of mining claims, and for the registry of the same, one dollar.

4. For the notices, summons and summary of dockets, at the rate of twenty cents for every ten lines or fraction thereof, and, besides, ten cents for the examination of each one of the leaves which are contained in the dockets and other documents to be included in the summary.

5. For the writing, comparison and countersigning of the certified copies, and for other copies, at the rate of one dollar for each 100 lines or fraction thereof.

6. For the search for dockets or for any other documents in the archives, one dollar.

When the parties in interest do not furnish sufficient data, and the search must be made among documents corresponding to more than one year, one dollar for each year of the search.

7. For each kilometer of going and for each kilometer of return, when traveled for the performance of any official duty, twenty-five cents.

8. For ocular examinations or exterior inspections, and making a report thereof, five dollars.

9. For inspections, official visits or examinations, in workings underneath the surface, five dollars for every 100 meters of depth, or fraction thereof, to which said workings extend, and five dollars for the report thereon.

10. For presence at meetings which do not exceed one hour of duration, three dollars; and for every hour or part of an hour over that time, one dollar. (R. L. min., Arancel.)

By a Circular of Fomento of September 1, 1892, the Mining Agents are authorized to charge one dollar for the comparison and countersigning of the plans presented by the expert surveyor, and the same for the comparison and countersigning of the copies of plans which may be copied from the archives of the Mining Agency by the parties in interest.

The Mining Agents have a right to charge only the above-named fees, and should consult with the Ministry of Fomento as to what should be the amount of their fees corresponding to cases not provided for by the Ministry. (R. L. min., Art. 8.)

The default in the payment of fees, if attributable to either applicants or opposers, implies for the first that they have desisted from their application for a concession, and for the second that they are to be considered as having desisted from their opposition and as consenting to all the claims which have been brought forward by the applicant. (R. L. min., Art. 36.)

VII. Mining Surveys and Mining Surveyors.

The measurement and laying out of mining concessions is to be done by graduate experts, or by practical experts if graduate experts are not at hand.

The Mining Law requires that within the three days next following the presentation and registry of an application for a mining concession, the Mining Agent must appoint a gradu ated surveyor expert, or, if none such is to be found in the place, a practical expert, who shall measure the claims and gores applied for and draw up the corresponding plan, marking clearly thereon the monuments (landmarks) of the claims or gores aforesaid, as well as the contiguous claims within a zone of at least 100 meters all around.

The Mining Agent may appoint the expert indicated by the applicant whenever said expert has the necessary qualifications. (R. L. min., Art. 19.)

The expert, within eight days after his appointment, must notify the Agent whether he accepts or declines the appointment; and, in the former case, that he has already made an agreement with the applicant with respect to the payment of the fees. The Mining Agent shall make a corresponding note thereof on the docket.

By desire of the applicant, the above term of eight days may

be prolonged by the Mining Agent, one single time only, for the same number of days more. (R. L. min., Art. 20.)

At the time of making the note of the acceptance of the expert, the Mining Agent shall fix for the expert a peremptory term of sixty days to present, in triplicate, the corresponding plan, accompanied by a detailed report; and he shall deliver to the expert a certified copy of his appointment, canceling thereupon a revenue stamp of ten cents for each leaf. The said copy shall conclude with the admonition that whoever may resist the performance of the field-work which the said surveyor has to carry on will be in danger of the penalties laid down in the law.

If the surveyors, in the performance of their work, actually meet with resistance, they shall demand the assistance of the public forces.

It has been expressly declared that surveyors, during the discharge of their duty, have the character of executors of a legitimate order of a public authority. (R. L. min., Art. 24, and C. Fom., July 6, 1892.)

The surveyor experts must pay attention to whatever observations may be made to them by the applicant (for the concession they are measuring), and by those who have opposed the application for the concession, or who propose to oppose it.

But they are not to express any opinion upon the observations, except in the explanatory report which they must present to the Mining Agency.

The presentation of said report within the peremptory term fixed by law is a personal responsibility of the experts, who shall be charged with all the loss and damages that may be caused by any default in the presentation of said document. (R. L. min., Art. 25.)

The operations on the field to be performed by the duly appointed surveyor expert shall be executed in such a manner that, by means of the necessary scientific processes, there shall be determined the horizontal lengths of the sides of the claims, and the angles formed by the aforesaid sides with the true meridian.

For this purpose the surveyor experts shall determine the magnetic declination of the compass, if that instrument is used to measure the courses of the sides.

Effort shall be made to refer some one of the vertices of the perimeter to fixed points found on the ground, and all the necessary data shall be collected for the verification of the work.

Landmarks.—The marking of mining claims upon the surface of the ground shall be made by means of monuments or landmarks, which must fulfill the following requisites:

1. They must never be changed from their position, since they are intended to mark points that are essentially invariable as long as the claims or concessions which they define continue unchanged.

They are to be solidly constructed, and must always be preserved in good condition, such repairs being made as may be necessary.

2. They must be situated in such convenient number and place that, in every case, from any one of them the preceding and the following one can be seen. By their form, color, or in some other way, they must be distinguished from neigboring landmarks.

Bearing in mind the foregoing instructions, the mining surveyor appointed by the Mining Agency shall mark upon the ground the points where the landmarks are to be placed. The surveyor shall also mark these points on the corresponding plan which he may draw up. (R. L. min., Arts. 3, 8 and 19.)

In case an increase of the number of claims in any mining concession shall be applied for, the landmarks must be placed upon the boundary-lines of the new property in accordance with the directions already given.

The same shall be done whenever there is a remeasurement (rectification) or a reduction of the number of claims. (C. Fom., September 3, 1892.)

Plans.—The plans of the claims shall be neatly and accurately drawn, on strong paper, for the preservation of the document, but the copies may be taken on tracing-cloth.

The scales must always be decimal and appropriate to the object of the plans.

The plans must show the length of the sides in meters, the directions of the same with reference to the true meridian, the declination of the compass used, with the date on which this was determined, and the area in hectares. (R. L. min., Art. 39.)

The surveyor appointed to measure any concession must present his plans to the Mining Agency within the peremptory period of sixty days, under his own strictest responsibility.

The plan must be in triplicate, showing the claims or gores that have been applied for, as well as the neighboring claims within a distance up to 100 meters.

One of the three plans (on strong paper) is to be placed in the docket, and the other two are regarded as copies thereof. All three must be compared and countersigned by the Mining Agent before the first plan is remitted to the Ministry of Fomento with the docket. (C. Fom., September 1, 1892.)

The plans and reports relative to mining concessions do not need revenue stamps. (C. Fom., October 19, 1892.)

In case the parties in interest should solicit copies of any plans existing in the archives of the Mining Agencies, the parties or persons designated by them for that purpose shall be permitted to make such copies on the premises of the Agency. (C. Fom., September 1, 1892.)

The responsibility which is incurred by the bad execution on the ground of the work of marking out and measuring the claims extends to the graduated surveyor expert, as well as to the simply practical experts. (C. Fom., July 1, 1892.)

The law does not exact the presence of the Mining Agent, nor that of any other authority, at the act of marking off and measurement of the claims. Hence, the applicants will not have to pay the costs which were formerly to be paid for said presence.

The want of said presence does not take away the necessary legality of the act, which is fundamentally a technical operation, and does not imply the occupation of property nor the infringement of any rights, the latter being guarded by the provisions of the law and its regulations. (C. Fom., July 1, 1892.)

The present mining law does not contain any fee bill for the payment of mining surveyors or experts, but there are in several States enactments covering these points; and for cases where they are not covered, the judges frequently use the scale of fees contained in the general fee bill of February 12, 1840.

VIII. Acquirement of a Mining Concession (Denouncements).

The words "denounce" and "denouncement," as applied to mining affairs in Mexico, came into the English language about 1827. H. G. Ward, in his book upon Mexico, published in 1827 or 1828, was the first or one of the first to use the term, and he defines it as follows: "To 'denounce,' in the Mining Code of Mexico, implies that process by which a legal right of possession is obtained to a particular portion of any vein, worked or unworked, known or unknown, which a miner chooses to select for his operations."

The word is almost equivalent to "announce" in English, and has no opprobrious significance whatever.

According to the earlier mining legislation of Mexico, the applications for mining concessions were called *denuncios* (denouncements); but the term is no longer in legal use under the present law, although it is still commonly employed in colloquial language when mining matters are discussed.

With respect to denouncements, the Transitory Article 1 of the Mining Law of June 4, 1892, says: "All denouncements of mines or of *demasias* (gores) which are in course of procedure when this law commences to take effect shall continue to be in procedure, and the necessary decisions thereon shall be made according to the present law."

Any inhabitant of the Republic may apply for a mining concession. See Foreigners and Foreign Companies, Sect. XV. of this Synopsis.

The law concedes complete liberty with respect to the number of claims* that may be applied for in any case where there is sufficient free ground, without taking into account whether the applicants are one or several, or whether they constitute a partnership or company, or not. (L. min., Art. 15, and C. Fom., July 1, 1892.)

With exception of the case in which the claims applied for are situated in ground subject to exploration, mining conces-

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* This clause has been woefully abused in practice. There are many persons in the Republic who have made and are making immense denouncements solely for the purpose of keeping mining ground tied up; and up to the present time the efforts of the Government to prevent this have had no decisive result.

sions are always to be conceded to the first applicant. (L. min., Art. 15.)

See Mineral Substances, Sect. I. of this Synopsis, for a list of the substances for whose exploitation a concession is necessary.

Every application for a concession to mine any of the substances which the owner of the soil is free to exploit shall be quashed at once. (R. L. min., Art. 44.)

Applications for the concession of mining claims or gores must be presented in duplicate to the proper Mining Agent, and must express with entire clearness the number of claims asked for; their situation on the ground; the location of the ground in the municipality to which it belongs; the most notable natural signs by which the claim can be identified; and the designation of the mineral substance which it is proposed to mine. To secure sufficient clearness, the Mining Agent may question the applicant himself, entering all his answers upon the application, on the duplicate thereof, and in the registry-book of the Mining Agency, in presence of the interested party. But inability or refusal of the applicant to give explanations shall not be a sufficient ground for not making the registry, or for the suspension of the rest of the procedure. (R. L. min., Art. 15.*) Applications for mining concessions made in the name of a third party may be admitted, always provided that the applicant shall give a bond, and shall promise to produce a legal power of attorney in proper form, at latest within the sixty days allowed to the expert to present his plans and report. If said period passes without the production of the power of attorney, it will be to the prejudice of the interested party. (C. Fom., October 15, 1892.)

Attorneys should be appointed by a power of attorney in legal form, if it is desired that the Ministry of Fomento shall deliver the titles to the attorney.† But, to avoid complications, the interested parties may, in their original application, or in a separate application to the Minister of Fomento, designate a person to whom the titles are to be delivered. (Special ruling of Minister of Fomento.)

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* See, however, on pp. 26 and 27 of this Synopsis, the analysis of Circular No. 32.

† A power of attorney in due form is required, for the purpose of obtaining prompt action upon a mining title before the Fomento Department.

It is not indispensable that in every case the applicant for a mining property shall have an attorney or representative in the City of Mexico to receive the titles to a property. As soon as the papers are approved and the necessary stamps provided, the titles will be sent to each interested party, without any expense to him. (C. Fom., July 1, 1892.)

On October 31, 1899, a circular (No. 32) of the Ministry of Fomento was issued, which states that cases have been very frequent where applications for mining concessions have been presented with the deliberate object of preventing other persons from taking up the same ground; and for the furtherance of this object a large number of *pertenencias* (claims) are asked for, or the number is not designated, as the documents simply claim the whole of a municipality, of a district, or of the jurisdiction of a Mining Agent, etc.

The circular then proceeds to explain the provisions of Article 15 of the Mining Law Regulations, and enjoins that the applicants for mining concessions must carefully and exactly comply with Article 3 of the Mining Law of June 4, 1892, and Article 15 of the Regulations.

According to this circular, the applications must contain:

(1) the number of claims (*pertenencias*) to be included in the concession, clearly and precisely stated; (2) the situation of these claims on the ground; (3) the location of the ground in the municipality; (4) the most notable natural marks by which the ground applied for can be identified; (5) the designation of the mineral substance proposed to be mined; (6) the nature and situation of the deposit in which the mineral is found, for which purpose it must be stated whether the mineral deposit is a vein, a blanket-deposit, a placer, or has some other form; (7) mention of the place or places, within the boundaries of the local Mining Agency, where the mineral deposit may be examined—designating the most notable landmarks by which the mineral deposit may be identified.

In case the application does not duly satisfy all these requisites, it cannot be admitted or registered.

This circular gives the latest and strictest construction of the law.

If the above requisites are fulfilled, the Mining Agent, if still

in doubt, may interrogate the applicant, and shall note his answers on the application, on the duplicate, and in the Registry Book of the Mining Agency, in presence of the interested party; but the proceedings must go on, *if the above requisites are fulfilled*, even if the party cannot give explanations, or refuses to do so.

The Mining Agent shall call the attention of the Ministry of Fomento, when the docket* is sent on, to the questions that were asked and the replies thereto.

As already noted on p. 11 of this Synopsis, applications for mining concessions in which interrupted claims—*i.e.*, claims not consecutive—are asked for are admitted whenever all the claims are in the same municipality and upon the same mineral deposit. Otherwise, separate applications must be presented with reference to the claim or claims situated in each separate mineral deposit or municipality.

In every case the applications must contain all the requisites above referred to, in order to be admitted. (C. Fom., October 31, 1899.)

A fifty-cent revenue stamp is required on every leaf of the application.

At such points of the Republic as may not be comprehended within the district assigned to any Mining Agent of the Ministry of Fomento, applications for mining concessions may be presented to the local postmaster, who, in such a case, shall receive them and take note thereof, designating the day and the hour of presentation.

The postmaster must also give immediate notice to the Ministry of Fomento by mail, and also by telegraph, where there is one. (R. L. min., Arts. 48 and 49.)

As soon as any application for a mining concession is presented to a Mining Agent, he shall proceed immediately to register the same, in the presence of the applicant, with an entry of the day and the hour of presentation, as well as the ordinal number of the docket relative thereto, in the special registry book for applications for mining concessions, and also

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* "Docket" is the best English equivalent I can find for the Spanish word *Expediente*.

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at the end of the application itself, and upon the duplicate thereof.

Said registry book is to be paged and countersigned by the Ministry of Fomento.

The applications shall be registered in the exact order of the date and hour in which they may be successively presented, without leaving any blank spaces in the book between the different registrations. (R. L. min., Art. 17.)

When an application has been admitted, no other can be received for the same site until after the Ministry of Fomento has entered a final ruling on the docket belonging to said concession, whether for full mining claims or gores. (R. L. min., Art. 16.)

In case of the simultaneous presentation of two or more applications for concessions of mining claims or gores for the same site, lots shall be drawn in the presence of the interested parties, to decide which of the applications is to be admitted and registered. (R. L. min., Art. 18.)

Within the three days following the presentation and registry of any application for a mining concession, the Mining Agent shall appoint a graduated mining expert, or, if there are none in that locality, a practical expert, to measure the claims or gores, and draw up the corresponding plan thereof. (R. L. min., Art. 19.) See Sect. VII. of this Synopsis.*

Within eight days (or sixteen, if the time be officially extended), the expert must communicate to the Mining Agent his acceptance or rejection of the appointment, and, in the first case, that he is already in accord with the applicant for payment of his fees. The Mining Agent shall enter the proper note thereof upon the docket, and designate at once for said expert a peremptory term of sixty days to finish and present his documents, giving him, at the same time, a certified copy of his appointment.

The Mining Agent shall then proceed to make out in duplicate a summary.

One copy of the summary shall be posted upon the Bulletin

* See pp. 20 and 21 of this Synopsis. The provisions there stated are substantially repeated here, as belonging under this Section also.

Board of the Agency, and the revenue stamps for this announcement shall be demanded from the applicant.

Said copy of the summary shall remain affixed on the Bulletin Board for one month, of which note shall be made on the docket.

The publication of the summary has the effect of a summons to any one who may believe he has a right to oppose the application for the mining concession of which the summary treats.

Opposition is only admissible during four months from the date of the summary, as posted on the Bulletin Board of the Agency.

When the four months above noted have passed without opposition being made, or if the opposition is not one of those which interrupt the procedure of the applications for mining concessions, or if the docket has been returned by the tribunals with a final sentence, favorable to the applicant:

Within fifteen days next following any of the above, the Mining Agents, under their strictest responsibility, must make a copy of the docket, and send the same, with the copies of the plan, in a registered letter, to the Ministry of Fomento.

If the applicant wishes to take charge of the delivery of said documents, the Mining Agent may deliver them to him, and shall notify the Ministry of Fomento. (R. L. min., Art. 34.)

The Mining Agents cannot suspend the procedure of any mining concession for any motive whatever, unless in cases of opposition. (L. min., Art. 19.)

Stamps.—As already noted (p. 27), applications for mining concessions must have a fifty-cent revenue stamp on each leaf.

The reports made of mining surveys, with the plans, do not require revenue stamps, since stamps are not required on the plans themselves. Neither should stamps be used on the copies of the docket, because the original docket must contain the stamps provided for by law, and also because said copies are and should be regarded as official memoranda. (C. Fom. of October 19, 1892.)

The copies to be given to the mining expert surveyors of

their respective appointments must have a ten-cent revenue stamp. (C. Hda. of October 29, 1892, and C. Fom. of November 12, 1892.)

Applications for a reduction in the number of claims must have a revenue stamp of fifty cents on each leaf. (C. Fom. of November 13, 1892.)

The prospecting permits made out unconditionally by private parties on their own lands do not cause any stamp tax; but if they contain any conditions, of whatever nature, the permits shall be considered as contracts, and must have a revenue stamp of fifty cents per leaf.

But the notice that must be given to the local Mining Agent before commencing prospecting work in public lands does not require, in any case, the use of revenue stamps. (C. Hda. of August 20, 1892, and C. Fom. of October 17, 1892.)

However, such copies of the prospecting permits as may be published on the Bulletin Board of the Mining Agency must have, on each leaf, a fifty-cent revenue stamp. (C. Hda. of April 5, 1898.)

Any default in the presentation of documents, affixing revenue stamps, publications, payment of fees, attendance at conciliatory meetings (*juntas*), and, in general, in any of the proceedings referred to above, which can be attributed to the applicants, will cause them to be held to have desisted from their application.

The docket formed by reason of any application for a mining concession is forwarded, after having passed through the preliminary stages, as above, to the Ministry of Fomento.

The docket is examined in the Ministry of Fomento, and, if approved, the making out of the title-deed will be proceeded with.

The deed will be remitted to the Mining Agent for delivery to the interested party, together with one copy of the plan, sealed by the Ministry of Fomento.

The Ministry of Fomento will send to the Treasury Department a detailed notice of the concession as made.

If the docket is not in form for approval, the proper observations thereon shall be made to the Mining Agent, so that the deficiencies noted may be corrected within a term to be

fixed by the Ministry of Fomento. If the said deficiencies are not so corrected, and are the fault of the applicant, the application shall be declared to have been abandoned by the applicant's delay; and an applicant thus declared dilatory cannot repeat the same application.

If the Mining Agent has caused the delay in the procedure, he will be held responsible, without prejudice to the applicant. (L. min., Art. 19, and R. L. min., Art. 37.)

Applicants are not under the necessity of appointing a representative (attorney in fact) in the Capital of the Republic to attend to the proceedings about the docket or to receive the title-deed.*

The title-deed will be sent to the Agent for delivery to the applicant, if he has not already designated, in the application itself or in another special writing sent to the Ministry of Fomento, some person in the Capital of the Republic who may receive the title-deed. (C. Fom., July 1, 1892, and a special ruling of the Ministry of Fomento.)

When the title-deed has been made out in favor of the concessionary, he enters at once into possession of his claim or claims without other formality. The title-deed produces all the legal effects of a transfer. (L. min., Art. 18, and C. Fom., July 1, 1892.)

IX. Amplification, Reduction and Remeasurement of Concessions: Withdrawal of Applications.

Amplification.—The owners of any mining property may ask for an increase of the number of their claims, and for this purpose must subject themselves to the proceedings laid down for applications for a concession.

The plan, which is to be drawn up by an expert in case of an increase of claims, shall include only the new claims which it is desired to acquire, showing the position of these with reference to the first property; the landmarks shall be placed upon the boundaries of the new concession. (R. L. min., Art. 42, and C. Fom., September 3, 1892.)

The applicants for a mining concession may ask for an in-

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* As to this, see note, p. 25.

crease of the number of claims therein before the publication of their application upon the Bulletin Board.

The Mining Agents shall note this application for increase on the first application, on the duplicate thereof, and in the Registry Book of the Agency, and shall also publish the summary of the application with the proper correction.

If the increase is desired after the publication of the summary, it will be necessary to withdraw the former application so that a new application may be at once presented. (C. Fom., August 1, 1892.)

Reduction.—The reduction of the number of claims, applied for or in actual possession, must be solicited in writing, with a fifty-cent revenue stamp on the application.

If the reduction is applied for before the publication of the summary, it will be sufficient to have the petition endorsed upon the original application, upon the duplicate, and in the Registry Book.

The summary should be published as corrected, and there will be no necessity of making a new application.

If the reduction is asked for after the publication of the summary, the original application must be abandoned, and a new application presented. (C. Fom., August 1, 1892.)

A reduction of the number of claims acquired under the new law does not require a new title-deed to the property.

The Mining Agent before whom the new application is presented, accompanied with the corresponding title-deed, shall appoint an expert, who, at the expense of the applicant, and within a convenient term which the Mining Agency shall allow for the purpose, shall make a plan of the reduced property, and shall locate the necessary monuments according to Regulations.

A reduction of the number of claims can only be applied for during the four months time allowed as above, and counted from the date of the posting of the summary on the Bulletin Board (page 29), or after the issuing of the title-deed. (C. Fom., January 17, 1901.)

The Mining Agent shall also make a note of the reduction, as asked for and as authorized, on the register of applications for concession and on the title-deed of the property, which shall

be delivered to the interested party, together with a certified copy of the proceedings.

The docket shall be terminated with the notice of the reduction, which should be immediately given to the local office of the Revenue Stamp Tax.

In the case of a reduction of the number of claims acquired before the mining law of June 4, 1892, the procedure will be the same; but in this case the Mining Agent must conform to the provisions of the circular sent out by the Ministry of Fomento on August 30, 1892.

The Mining Agent must make due mention of all cases of reduction of the number of claims in the monthly report which he has to forward to the Ministry of Fomento. (C. Fom., September 3, 1892.)

If the reduction of the number of claims should be made before the expiration of the term of four months, which the law allows for the completion of the docket relative to any concession, it will not be necessary that the interested party should desist from his original application.

In such cases the following procedure shall be observed:

First.—If the application for a reduction should be presented before the surveyor expert has made the survey, the Mining Agent shall give notice to the surveyor, so that the survey shall be made in accordance with the desires of the party in interest.

Second.—If the expert shall have already presented his report, the Mining Agent shall make a new appointment, so that the reduction may be made at the expense of the applicant, and within a term which shall not exceed the time remaining for the expiration of the four months allowed by law for the surveys.

In either case the Mining Agent shall make a note of the reduction in the docket, and shall bring it to public notice by means of the official newspaper of the State, and by a notice on the Bulletin Board of the Agency.

It is understood that the publication made in the newspaper shall be at the expense of the interested party. (C. Fom., November 20, 1893.)

The time for the publication of the notice shall be fifteen days.

New applications for the concession of ground now left free shall only be admitted and registered after the expiration of said term.

The party interested in the reduction shall be obliged to present to the Mining Agent, before the termination of the proceedings relative to his application, one copy of the official newspaper in which the proper publication has been made.

If the reduction shall be applied for, and if any requisite of the law or regulations has been uncomplied with in the anterior procedure, the Mining Agents shall note the circumstance in the docket relative thereto; the reduction shall not be proceeded with; and, when the proper term has expired, the docket shall be forwarded to the Ministry of Fomento for the corresponding decision relative thereto. (C. Fom., March 1, 1897.)

Remeasurement.—Whenever a remeasurement is applied for, it shall be subject to the same procedure and requisites as are determined for mining concessions. (R. L. min., Art. 42.)

For the purpose of explaining the anterior provision of the law, the Ministry of Fomento, by circular of September 3, 1892, prescribed the following: In cases of rectifications, when it is only sought to repeat the measurement of the claims on the ground, in order to place them exactly in agreement with the title-deed, the procedure will be the same as for a new concession, and the monuments, or landmarks, should be placed according to Regulations; but as the making out of a new title-deed is not required, the docket must terminate with the delivery, which the Mining Agent will make to the interested party, of a certified copy of the operations as practiced.

But if the purpose of the rectification is to correct any errors that may exist in the title-deed, the law demands the drawing up of a new title-deed, and hence the entire proceeding is the same as for new concessions.

Withdrawal of Application.—An applicant may withdraw an application for a mining concession, after or before the publications, by appearing in person, or by writing.

If the withdrawal is made before the publications, and by appearance, it will be sufficient for the appearance to be spread upon the docket; the minute to be signed by the applicant for the docket and placed in the archives.

If the withdrawal should be made in writing, the document

shall be added to the docket, which shall then be placed in the archives.

If the withdrawal should be made during the publication of the advertisements, these shall be taken down from the Bulletin Board of the Agency where they are being published, and the same procedure shall be followed as in cases of withdrawal by appearance or in writing before publication.

In the case of a voluntary withdrawal, when all the legal requisites have been complied with in the proceedings upon the docket, the Mining Agents shall proceed to make a proper publication thereof on the Bulletin Board for a period of fifteen days, and until this period is concluded no applications for a concession which may be presented, covering the same ground, shall be received or registered.

If the application for a withdrawal shall have been presented in any case in which the requirements of the Law and of the regulations shall not have been fully complied with in the anterior procedure, the Mining Agents shall note the non-compliance in the respective docket, the application for withdrawal shall not be acted upon, and when the time laid down in the regulations has expired the docket shall be remitted to the Secretary of Fomento for an appropriate disposition of the same. (C. Fom., March 1, 1897, Secs. 3 and 4.)

It should be noted that any omission in the presentation of applications, the supplying of stamps, publications or advertisements, payment of fees, attendance upon hearings, and, in general, the omission of any one of the proceedings prescribed for the obtaining of a mining concession or for making opposition thereto, whenever such an omission is imputable to the applicant or to the opposers, will be the cause, for the applicants, of considering them as having desisted from their application for a concession, and for the opposers of considering them as having desisted from their opposition and as being in conformity with the claims brought forward by the applicants. (R. L. min., Art. 36.)

X. Proceedings in Opposition: Mining Litigation: Penal Jurisdiction.

The publication of the summary in each case of application for a mining concession has the effect of a summons to all those

who may believe that they have a right to oppose the application in question. (R. L. min., Art. 22.)

Any opposition that is commenced against an application for a mining concession must be presented within the four months ensuing from the date of the summary, which is published in every case on the Bulletin Board.

Apart from this, any opposition, to be admissible, must be founded upon one of the following motives:

1. Nonconformity of the owner of the ground.
2. Invasion of contiguous claims or gores.
3. An anterior property in or application for the claims or gores now applied for, or some part thereof. (R. L. min., Art. 26.)

If the opposition should be founded upon some other motive, different from the three just mentioned, the Mining Agent shall confine himself to attaching the document to the docket, without suspending the course of the latter. (R. L. min., Art. 32.)

When opposition is made by the owner of the ground, alleging that the mineral deposit in question does not exist, and when from the report of the surveyor expert it appears that there are indications of the mineral on the surface of the ground, or a prospect-hole, or prospect-work of any kind in the deposit itself, the Mining Agent shall decline to hear the protest, and shall continue the proceedings on the administrative docket until their termination, so that the Ministry of Fomento may award to the applicant the property in question, which is understood to be only the underground mineral right. In any case, the area and price of that part of the surface to be occupied by the miner are always subject to a judicial decision. (L. min., Art. 20, and R. L. min., Art. 30.)

In the case that there are no indications of a mineral deposit on the surface of the ground, nor any prospect hole, or exploration of any kind, see under *Expropriation*, Sect. XII. of this Synopsis, for the course to be followed. The court will decide whether a mining concession is to be granted or not, and the decision may be appealed from.

Except in the two preceding cases, the Mining Agents shall suspend the proceedings upon applications for concessions, whenever an opposition is presented thereto. (L. min., Art. 19.)

Whenever an opposition is presented, the Mining Agent shall advise the applicant thereof by means of a notice, during three consecutive days, on the Bulletin Board (of the Agency), giving the name of the opposer and of the applicant, and the ordinal number of the docket corresponding thereto. In this docket shall be made a note of said notice being published. (R. L. min., Art. 27.)

Except in the case that the applicant may present himself in the Agency to manifest that he withdraws his application, the Mining Agent shall order the document of opposition to be reserved until he shall receive the report and plan of the surveying expert. (R. L. min., Art. 28.)

On the same day in which the latter documents are received, the Mining Agent shall summon the interested parties (applicants and opposers) to a meeting within the next fifteen days, by means of a notice on the Bulletin Board during three consecutive days, in which notice shall simply appear the number of the docket, the names of the interested parties, and the day and hour of the meeting.

At the meeting the Mining Agent shall endeavor, above everything, to reconcile the dissentients and to avoid judicial questions. A note of all these points shall be made on the docket. (R. L. min., Art. 29.)

If the Mining Agent does not cause an agreement between the interested parties, he shall suspend all proceedings and deliver the docket to the applicant, so that under his responsibility, and within a prudent term to be fixed by the Mining Agent, said applicant shall present the docket to the local Judge of First Instance, to whom it may belong. (R. L. min., Art 31.) See below, in this Section.

When the opposition has been presented after the plan and report of the surveying expert have been received, but before the expiration of the four months' term fixed by law, the above proceedings for an agreement shall be followed as far as applicable, this being the only case, except that in which the docket is to be sent to the courts, in which the Mining Agencies may postpone the proceedings up to thirty-five days beyond the four months prescribed for the procedure in the docket, provided that the opposition shall be presented less than twenty days before the day on which the term of four months is to expire. (R. L. min., Art. 33.)

When the aforesaid four months shall have expired without any opposition appearing, or if the opposition is not one of those that interrupt the procedure, or if the docket has been returned from the Tribunals with a final sentence favorable to the applicant, the Mining Agency, under the strictest responsibility and within the next fifteen days, shall make a copy of the docket, and shall remit the same, together with the copies of the plan, in a registered package, to the Ministry of Fomento, unless the applicant prefers to take charge of the forwarding of said documents, in which case the Mining Agency shall so inform the Ministry of Fomento. (R. L. min., Art. 34.)

Mining Litigation.—Any lawsuits about mining matters shall be carried on in the Federal District, or in the Federal Territories, or in any State, by the judges and tribunals which may there be competent, according to the provisions of the Code of Commerce, observing the rules laid down in Book IV., Title I., Chapter IX., of the said Code, with the condition that the preferential working expense, indicated in Article 1030 of said Code, Sec. II., is the payment of the mining tax. (L. min., Art. 27.)

Penal Jurisdiction.—The crimes and misdemeanors committed officially by the Mining Agents shall be tried before the District Judges (Federal Judges) acccording to the proper laws.

Common crimes and misdemeanors committed in the mines shall be subject to the jurisdiction of the local judges, without prejudice to the power of the Federal authorities to impose a ministerial punishment. (L. min., Art. 31.)

XI. Metallurgical Works.

The term *hacienda de beneficio* is applied most usually to mills where gold- and silver-ores are treated by amalgamation.

The establishment and working of amalgamation-mills, as well as that of all classes of metallurgical works, is governed by the provisions of the ordinary laws; that is to say, by the same laws as apply to the establishment of any other kind of industrial or manufacturing business, and as relates to taxes thereon by the Law of June 6, 1887, Arts. 7 and 8.

Said law provides that amalgamating-mills and metallurgical works, when in operation, shall pay to the State where located,

or to the General Government, if in the Federal District or in the Territories, as the only tax, which cannot be increased, up to six dollars per thousand upon the value of the buildings, with their machinery, and that every other tax, except the Stamp Tax, is strictly prohibited.

The products of metallurgical smelters, in the form of argentiferous lead, are exempt from exportation duties up to a content of 7 thousandths of silver, whenever it shall have been so specified in special contracts.

The excess of silver over the above content shall be subject to the payment of duties. (C. Hda. of February 25, 1892.)

Metallurgical establishments, working under prior contracts with the Government, in force on March 27, 1897, are excepted from the payment of the Coinage Tax upon the silver they may export directly, as long as the silver content of the argentiferous lead does not exceed 7 thousandths and the silver content of the argentiferous copper is not over 20 thousandths.

If these limits are exceeded, the said establishments must pay the Coinage Tax upon the excess.

This exemption only applies to the products originating in the establishments that have a franchise, but not to the products which these may acquire from other establishments. (L. met. prec., Art. 9.)

Metallurgical companies may obtain a special concession from the Secretary of the Treasury to effect, in their own establishments, the presentation of the products intended for export, so that the local Federal officers may thereupon perform the assays and form the account of the taxes and duties to be paid.

The establishments exempted, under contract, from the payment of Coinage Tax upon argentiferous lead and copper of a less amount than 7 and 20 thousandths of silver, respectively, must, when they employ the products of other metallurgical establishments, pay the 2 per cent. Coinage Tax upon the total value of the silver contained therein before such products are employed for subsequent operations.

The origin of their products must be proven by metallurgical establishments at the Custom House or in the Government assay offices, in the manner laid down by law. (R. L. met. prec., Art. 2.)

Concessionaries under the law for the exploration and working of gold-mines and placers, published June 6, 1894, should have installed, within the minimum term of two years from the date of their contract, a metallurgical establishment with sufficient capacity to treat 400 tons of ore weekly, or, in place of said establishment, some other works equivalent in value to said establishments, at the discretion of the Secretary of Fomento.

NOTE.—Water-rights for mining or metallurgical purposes, if upon navigable or floatable streams, would have to be acquired from the Federal authorities, under the provisions of a special law to that effect.

Upon other streams the water-rights would have to be acquired by concession from the Government of the State where located.

XII. EXPROPRIATIONS FOR MINING PURPOSES.

The marking out and measurement of the mining concession does not imply any right to the occupation of the surface property. The owner of the mining concession should understand that he must arrange with the owner of the land, whenever he may find it convenient to do so, for the acquirement of such a part of the surface as he may need to occupy for the dependencies of his mining business, or of the totality of the surface marked out for his mining claims (in the case of placers or superficial deposits).

This arrangement may be amicable, through a contract with the owner, or by expropriation, through initiation of the proper legal proceeding. (R. L. min., Art. 40.)

The workings required for the exploitation and utilization of mines and placers are considered to be of public utility, wherefore, in case of disagreement, there may be a forcible expropriation of the ground necessary for such purpose. (L. min., Art. 10.)

If, for any reason, the owners of a mining concession cannot agree, either upon the area of the land which it may be necessary to occupy for the exploitation of mines and placers, or upon the price thereof, with the owners of the surface ground, the expropriation shall be decreed by the Judge of First Instance, observing the following procedure:

1. Both parties shall appoint their own expert appraisers, who shall present their estimates to the judges within the eight

days following, counted from the day on which they were appointed.

If the estimates should be discordant, the judge shall appoint a third expert as umpire, who must present his opinion within an equal period.

The judge, taking into account the opinion of the experts and the proofs which may have been rendered by the parties while the experts were forming their report, shall determine within the following eight days the superficial extension that is to be occupied and the amount of the indemnity.

The decision of the judge shall be carried out without further recourse than that of responsibility (of the judge).

2. If the owner of the ground to be occupied should not appoint his expert within the term of eight days after being notified by the judge, the latter shall appoint judicially an appraiser who will represent the interests of the land-owner.

3. If the possessor or owner of the property should be unknown or doubtful, the judge shall determine, as the amount of the indemnity, the sum which may be the result of the examination by the appraiser appointed by the concessionary of the mine and the appraiser appointed by the judge to represent the legitimate owner. Said sum shall be placed on deposit, to be delivered to the person to whom it may belong.

NOTE.—The mining laws make no provision for the expropriation of water or of wood.

The right of way to mines and to open roads would have to be obtained under the ordinary provisions of the Civil Code in force where the mines might be located.

XIII. EASEMENTS AND TUNNEL-RIGHTS.

Mining properties and common properties—*i.e.*, real estate not used for mining purposes which adjoins mining properties—shall possess and enjoy (or suffer, as the case may be) the legal servitudes of right of way, right of aqueduct, right of drainage, and right of ventilation.

For the imposition of said servitudes, and for the assessment of damages corresponding thereto, the judges shall subject themselves to the laws of each State, and to those of the Federal District, and of the Territories, when said laws are not modified by the following rules (L. min., Art. 12):

1. The legal servitude of drainage consists of the obligation

which the owner of one claim incurs to indemnify the proprietor of another claim for loss and damages which may be occasioned by not maintaining the said drainage of the subterranean workings, or by not maintaining the said drainage as much as may be necessary, so that the water flows from the first to the second claim.

Also, in the obligation which all claim-owners have to permit, through their claims, the passage of tunnels or counter-mines, whose exclusive object is the drainage of one or more workings.

2. Drainage-tunnels, when not made by mutual agreement, may only be undertaken by the owner or owners of certain claims, for which the said tunnel is an absolute necessity.

3. For the case provided for in the foregoing rule, all the owners of claims that are improved by the drainage secured by means of the tunnel are bound to pay an indemnity in proportion to the benefits received, account being taken of the nature of each mine, and according to the state thereof.

4. The opening of mining-tunnels shall not be commenced without previous license, conceded by the Ministry of Fomento, after hearing the opinion of the local Mining Agent, and after examination and approbation of the plans upon which are detailed the course and cross-section of the proposed tunnel. See Rule 22.

5. Any pay-ore which may be found while opening the mining-tunnels, if it is found within claims that have been legally conceded, is the property of the owner of such claims; and if it is found within free ground, it shall be divided between the owners of all the claims improved by the mining-tunnel, according to the proportions laid down in the foregoing Rule 3.

6. If, where a mining-tunnel has been undertaken, one or more veins in free ground are discovered thereby, and if application is made for the concession of the respective claims or gores, the rules as to applications for concessions shall be applied.

The tunnel-owners in this instance shall be considered as explorers; so that, during three months subsequent to the notification, applications for the concession of the claims in question can be accepted from them only.

7. Whenever the Ministry of Fomento has authorized the license referred to in the foregoing Rule 4, only by express contract can any other persons, apart from those that are mentioned in the license as benefited by the mining-tunnel, be considered as undertakers of the tunnel.

8. The owners of claims traversed by the drainage-tunnel may place their own confidential inspectors within their respective claims while the tunnel is being opened. The functions of the inspector are limited to watching the work, and reporting to the Mining Agent, or to the corresponding judge, in the proper case, such abuses as he may observe.

9. At those points of drainage-tunnels where they communicate, for any reason, with mine-workings, gratings shall be fixed as soon as the communication is opened, to prevent transit or passage.

10. Only in case of unanimous consent, expressed in a public deed made by all the interested parties in a general drainage-tunnel, according to the foregoing Rule 3, may said tunnel be destined to other uses than to those of drainage.

In this case there shall be stipulated in the contract, under penalty of nullity, all the particulars referring to passage or transit, such as are indicated in the foregoing Rule 9.

11. Mines which may be newly opened, at a point where they may be benefited by a general drainage-tunnel already in existence, shall be subject to the foregoing Rules 3, 7, 8, 9 and 10.

12. The legal servitude of ventilation consists of the obligation, which every owner of mining-claims assumes, to permit the proprietors of contiguous claims to open communication with his interior workings, whenever such communication will produce, as a necessary result, a ventilation which could not be obtained in any other manner, except at great expense.

13. Unless there is an express contract to the contrary, drawn up in the form of a public deed, between the owner of the dominating property and the owners of the serving property, gratings to prevent passage or transit shall always be placed upon the boundary-line of the respective properties.

14. Whenever a communicating working, not among those mentioned in the foregoing Rule 12, shall, in fact, ventilate

two or more workings, this service of ventilation shall not confer on the mine-owner who opened the communication any right to demand compensation from the owners of the other workings so ventilated, nor shall the said owners, in their turn, acquire any legal servitude as an encumbrance upon the mining property which causes the ventilation.

15. If pay-ore should be met with during the progress of a working opened for the purposes indicated in the foregoing Rule 12, the provisions of Rules 5, 6 and 8 shall be observed wherever applicable.

16. Also, whatever is applicable of Rule 4 shall be observed.

17. All the expenses that may be incurred by the workings which are to be opened to secure ventilation, and those of the subsequent ventilation of the same, shall be at the exclusive charge of the person who solicited the constitution of a servitude.

18. In the future, for the imposition of a legal servitude, as an easement of any mining property, or as an encumbrance to another, there shall be required, either the consent of the owner of the serving property, expressed in a public deed, or by a declaration signed and ratified before a judicial authority, or before the Ministry of Fomento; an administrative decision, consented to by the interested parties; or a judicial decision.

19. The owner of claims in whose favor it is supposed that a legal servitude is to be established, but who does not succeed in securing the consent of the party by whom it is presumed the servitude should be granted, must present himself before the Ministry of Fomento.

The Ministry, with the formalities and within the term prescribed by the Regulations, shall decide whatever it may deem proper, but always after a hearing of the dissident.

If the latter party or the applicant should not be willing to abide by the administrative resolution, the right shall be reserved to appeal to the proper local tribunals, within the term fixed by the Regulations.

The final decision shall be communicated by the tribunal which pronounces it to the Ministry of Fomento.

(See Rules 23 and 24.)

20. If the administrative decision should be favorable to the applicant, and adverse to the opposer, said decision can only be immediately put into effect after the filing of a proper bond by the applicant to compensate losses and damages, in case the opposer should obtain a final decision in his favor before the courts.

21. The three preceding rules are applicable to all the cases in which the provisions of any of the other rules shall or might give rise to a judicial question. (L. min., Art. 12.)

22. For the imposition of the servitude of a mining tunnel, as referred to in the foregoing Rule 4, there shall be presented the application made to the local Mining Agent for a permit, which shall be accompanied by the horizontal projection (plan) and section of the tunnel, both to an appropriate decimal scale, as well as the sections and other details which are believed to be proper to illustrate the nature and circumstances of the projected works.

The Mining Agent shall forward to the Ministry of Fomento, together with the application and the corresponding plans, a report upon the subject, which shall contain his own opinion, founded on the data.

The said Ministry, in view of said documents, and of any other data which it may think proper to ask for, shall decide upon the proper course. (R. L. min., Art. 45.)

23. The owner of any mining claims, in whose favor it is supposed that an easement ought to be established, and who does not obtain the consent of the person by whom it is supposed the servitude should be borne, may present to the Ministry of Fomento, in accordance with the provisions of the foregoing Rule 19, the corresponding application, accompanied by all the necessary data.

The Ministry, in view of the report of the local Mining Agent, and previously hearing the dissident, or his representative, shall determine whatever it may think proper within the terms which it may fix, under the circumstances of each case. (R. L. min., Art. 46.)

24. If the applicant for the easement referred to in the same foregoing Rule 19, or the party who should bear the servitude, should not be willing to conform with the corresponding decision of the Ministry of Fomento, he may go before the

proper judge, provided he shall do so within a term of not to exceed two months from the date of said decision. (R. L. min., Art. 47.)

That part of the tunnels situated outside of boundary lines is exempt from the mining tax, when the said tunnels are exclusively designed for ventilation, drainage, and the extraction of minerals which do not come from the tunnel itself. (L. min., Art. 33.)

XIV. Mining Contracts and Companies.

A contract in virtue of which money or goods are furnished to the owner of a mine for the working thereof was called *avio* (for which the nearest English equivalent is *habilitation*) in the older mining laws of Mexico.

Such a contract is at present either a partnership or a mortgage. (L. min., Art. 25.)

The mining law of June 4, 1892, provided expressly in Article 5, transitory, the following:

The contract of *avio*, and all contracts relative to mining affairs which may be in existence when this law commences to be in force, shall be construed by their own stipulations and on omitted points according to the mining legislation in force at the time when the contracts were made.

But it shall be indispensable for the validity of future acts depending upon said contracts that said contracts should be registered according to the provisions of Articles 24 and 25 of this law within the term of one year from the time of the law coming in force.

In consequence, if in any case a mining business is transferred by any title to a third party, said third party shall be bound by all obligations proceeding from the contracts referred to, since these produce realty rights of action in law.

Stock-companies or partnerships that may be formed for the exploitation of mines shall be governed by the provisions of the Code of Commerce, except those relating to monetary associations, which are not applicable to mining business. (L. min., Art. 24.)

Note.—The part of the Code of Commerce above referred to comprises Articles 268 to 271, inclusive, which are not applicable to mining affairs.

Every mining company or partnership is obliged to register itself at the county seat of the county or judicial district where the mining-claims that form the object of the business are situated, as well as at the domicile or domiciles which the said partnership or company may have in the Republic. (R. L. min., Art. 54.)

XV. Foreigners and Foreign Companies.

Foreigners enjoy in the Mexican Republic the same civil rights as the citizens thereof and the guarantees of the Federal Political Constitution, Sec. 1, Title I.

Foreigners may therefore apply for prospecting permits and mining concessions, and have the same awarded to them, provided they are not located within the twenty-league limit.

It is to be noted that any foreigner who may acquire real estate (including mines) in the Mexican Republic, and who does not manifest, at the time of said acquisition, his intention to preserve his nationality, is reputed to be a Mexican citizen. (Federal Political Constitution, Art. 30, Sec. III.)

According to the law of February 1, 1856, still in force, no foreigner can acquire, without previous permission, real estate in the frontier States or Territories, unless at twenty leagues distance from the frontier line.

Whenever a foreigner shall present an application for a concession to acquire any mining property located within the above-named limit, he must send, at the same time, his application for permission, through the local Governor, to the Ministry of Fomento, so that the said permission may be passed upon, in one or the other sense, whenever the period may arrive for the granting of the title to the mining concession as applied for. (C. Fom. of September 5, 1892.)

As to the registry of foreign corporations that may desire to establish themselves or to found branch houses in this Republic, see Sect. XVI. of this Synopsis.

Foreigners who have applied for mining concessions within the twenty-league zone above referred to must present the authorization of the Government to hold mining property within the zone within the period of four months, which is fixed according to law for the completion of the docket relative to the concession. (Page 29 of this Synopsis.)

Foreigners who may acquire mining property are subject, in everything that relates thereto, to all the laws in existence or that may be framed hereafter relative to the transfer, use and preservation thereof, as well as to the payment of the respective taxes.

Said foreigners cannot at any time plead any rights as foreigners with respect to the above matters. (Law of February 1, 1856, Art. 5.)

Consequently, all questions with respect to mining property owned by foreigners in this Republic must be tried before the Tribunals of this Republic and according to its laws, to the exclusion of any foreign intervention whatever. (Law cited, Art. 6.)

Any contract for the rental of mines made with a foreigner for a longer term than ten years is to be reputed as a transfer of the property. (Law of May 28, 1886, Art. 31.)

Foreign corporations in Mexico enjoy the same rights as are conceded to them by the laws of their own country, provided that these rights are not contrary to the laws of the nation. (Law of May 28, 1886, Art. 5.)

XVI. Registry of Mining Transactions.

The offices which have charge of the public register of property; in default of these, the mortgage offices; and in default of both, the Judges of First Instance of the common (State) law, shall keep an especial book for the registry of mining transactions. (L. min., Art. 25; R. L. min., Art. 51; and Code of Commerce, Art. 18.)

Registration is obligatory with respect to contracts of partnership or of companies, and is optional with respect to title-deeds of mining concessions or property.

The Register Book is to be filled up according to the chronological order of the presentation of documents, and the following items must be inserted therein, as nearly as may be:

1. The name, title or social designation of the concern.

2. The class of operations to which the concern is devoted.

3. The date on which it will commence or has commenced its transactions.

4. Its domicile, specifying the branch-houses it may have

established, although these branches must also be registered where situated.

5. The contracts of association of every partnership or company, whatever may be its object or denomination, as well as the contracts for modification, abrogation or dissolution of the same.

6. The minutes of the first general meeting and the documents annexed thereto, in the case of stock-companies which were organized by public subscription.

7. General powers of attorney, appointments, and the revocation of the same, if such were conferred upon managers, agents, employees or other representatives.

8. The record of the increase or decrease of the money-capital of stock-companies or partnerships.

9. Title-deeds of mining property.

10. Issues of stock-loan certificates and bonds, giving the series and numbers of the certificates of each issue, their interest and payment terms, the total quantity of the issue, and the goods, works, franchises or mortgages (when there are such) which are responsible for the amounts.

Stock or obligations emitted by private parties should also be registered in the same way. (Code of Commerce, Art. 21.)

Failure to register the said title-deeds and other papers cannot affect unfavorably the rights of third parties; but said third parties may legally profit by such failure.

Notwithstanding the omission of the mining registry, any documents referring to real estate and to real property rights shall be valid against third parties whenever they may have been registered according to the common law. (R. L. min., Arts. 52 and 53, and Code of Commerce, Art. 26.)

The mining registry shall be made at the seat of government of the county or judicial district where the mine is located, and, if a mining company is in question, also at the domicile thereof.

If, from the extension of the claims (*pertenencias*), or for any other motive, there should be a doubt as to where the registry is to be effected, the Ministry of Fomento shall decide, and must communicate its decision to the Treasury Department. (R. L. min., Art. 55.)

The inscription shall be made with the certified copy of the respective deed in hand, or from the document itself, or from the written declaration which the interested party may present, whenever the deed to be registered may not be a "public document." (Code of Commerce, Art. 25.)

NOTE.—A "public document" is one drawn up before a notary public, or some official of equal authority, or by some public officer, administrative or judicial.

Documents proceeding from foreign countries, and subject to registration, shall be previously protocolized in the Republic. (Code of Commerce, Art. 25.)

NOTE.—When a document from abroad is to be protocolized in Mexico, it must be certified to by an Ambassador, Minister or Consul of Mexico. This certificate is certified to by the Foreign Office here. The document is then ready to be protocolized—that is, spread upon the record of a Notary Public—if it is in Spanish.

If not in Spanish, it must be presented, with a translation, to some Court of First Instance in this Republic.

The Court appoints an interpreter to ascertain and certify the correctness of the translation, and the order is then given for the document to be put on record by the Notary Public. In any case the Notary retains the original document among his records, and issues a certified copy thereof, in Spanish, for use, which copy has the legal effect of the original document.

The Registers cannot in any case, or for any motive, refuse the entry of the documents that may be presented to them. (R. L. min., Art. 51, and Code of Commerce, Art. 31.)

Documents duly registered produce their legal effects from the date of the entry, and cannot be invalidated by anterior or posterior documents not registered. (R. L. min., Art. 51, and Code of Commerce, Art. 29.)

Foreign companies or houses which may desire to establish themselves or to establish branch houses in the Republic must present and have entered in the Register a certified copy of their statutes, contracts and other documents referring to their organization; also, their inventory or last balance-sheet, if they had one; also, a certificate of being constituted and authorized according to the laws of their respective countries.

This certificate must be made out by the Minister accredited by this Republic to that country, or, in default thereof, by the

Mexican Consul. (R. L. min., Art. 51, and Code of Commerce, Art. 24.)

Any change of ownership of a mining property must be notified to the Mining Agent or other officer in charge of the Register, so that the proper note can be made thereon. (L. imp., Art. 7.)

The Mining Agents of the Ministry of Fomento shall also keep a registry-book, paged and countersigned by the Ministry of Fomento, in which must be registered all applications for the concession of mining claims or gores that may be presented.

This registration shall be made immediately, in the presence of the applicant, with an entry of the day and hour of presentation, as well as the number of the respective docket.

Blank spaces are not to be left in the book between the several entries, and these must, in every case, be exactly subject to the order of their dates and of the hours in which they were presented. (R. L. min., Arts. 15 and 17.)

If two or more applications for a concession of mining claims or gores, covering the same site, should be presented simultaneously, lots shall be drawn, in the presence of the interested parties, to decide which of the applications is to be admitted and registered. (R. L. min., Art. 18.)

In the same registry-book the Mining Agents shall enter such reductions of the number of mining claims as are applied for and conceded. (C. Fom., September 3, 1892.)

XVII. Taxes on Mines.

Caducidad (Loss of Mining Property).—The default of payment of the tax constitutes the only cause of the loss of mining properties, which in this case become free of all liabilities and may be adjudicated to the first applicant who shall fulfill the legal requisites. (L. min., Art. 29.)

The tax upon mining properties is a Federal tax, and is composed of two portions—one portion to be paid but once in revenue stamps, which are to be affixed to every title-deed to mining property, and the other to be paid annually. (L. min., Art. 28, and L. imp., Art. 1.)

The Tax Upon Mining Title-Deeds.

The revenue stamps for the title-deeds to mines of gold, silver and platinum shall be of the value of ten dollars, and shall be placed upon the said title-deeds at the rate of one revenue stamp for each claim (*pertenencia*) of ten thousand square meters, or fraction of a claim which is equal to, or more than, the half thereof. (L. imp., Arts. 1 and 3, and L. of June 3, 1898, Art. 1.)

When the fraction shall be less than half a claim (whether this fraction is the whole property or whether it constitutes an excess over several claims), a revenue stamp for five dollars should be placed upon the first leaf and another revenue stamp of fifty cents upon the second leaf of the title-deed.

The title-deeds to mines which are not of gold, silver or platinum, and which require a legalized concession for their working, need only carry revenue stamps to the value of two dollars and fifty cents for each claim.

But these same mines shall carry the same stamp-tax (and other taxes) as those of gold, silver and platinum when the minerals found in said mine contain gold, silver or platinum in any proportion. (Law of June 5, 1898, Arts. 1 and 2.)

According to the law of October 31, 1892, the value of the revenue stamps which should be affixed to the title-deeds of mines or deposits of iron and mercury should be one dollar per claim (*pertenencia*); but the article referred to was repealed by the decree of June 3, 1898, according to which the revenue stamps on the title-deeds to such mines are to be of the value above stated.

The revenue stamps to be placed upon the title-deeds to mining property shall be canceled by the Ministry of Fomento, which Ministry will call upon the interested parties for the revenue stamps, either directly or through the local Agency, as soon as the docket has been approved and the title-deeds authorized to be made out. (L. imp., Art. 3, and C. Fom., Sept. 1, 1897.)

By the Mining Tax law of June 6, 1892, every mine-owner, or possessor, at that time and by any title, was obliged to present his documents in the local Sub-Treasury office within a fixed time, to have the proper revenue stamps affixed to his title, and also that a note might be made in the Register of

the number of *pertenencias* in the property for the payment of the annual contribution. The time for the above finally expired October 31, 1892.

Annual Mining Taxes.

Every owner or possessor of mines not of gold, silver or platinum, and for whose working a legal concession is required, is obliged to pay annually the sum of two dollars and fifty cents for each *pertenencia*. (L. of June 3, 1898, Arts. 1 and 4.)

For mines of gold, silver or platinum the owners shall pay ten dollars per year for each *pertenencia* (claim of 10,000 square meters). (L. imp., Art. 4.)

The mines first referred to above shall pay an annual tax equal to that of the mines of gold, silver and platinum when the ores encountered therein contain gold, silver or platinum in any proportion. (L. of June 3, 1898, Art. 2.)

Iron-mines or deposits, in whose favor an exception was established with respect to the annual impost of the law of October 31, 1892, have now become subject to the general law, according to Article 4 of the law or decree of June 3, 1898.

Fractional parts of a *pertenencia*, less than one-half of a claim (less than 5000 square meters) are exempt from the annual tax. (C. Fom. of February 16, 1898.)

Fractional parts of a *pertenencia* equal to or more than one-half a *pertenencia* (equal to or more than 5000 square meters) pay the same annual tax as an entire *pertenencia*. (L. imp., Art. 1.)

The annual tax is collected by thirds of a year, in advance, through the offices of the Revenue Stamp Tax, to which the taxpayers must peremptorily present themselves without the necessity of a notice or of any other requisite on which might be founded a delay or excuse. (L. imp., Art. 5, and R. L. imp., Art. 17.)

The offices just referred to are the principal or subordinate Administrations of the Stamp Tax, but the Secretary of the Treasury may assign other offices to receive the tax in such cases as he may consider it just or convenient to do so, by giving notice to the General Administration of the Stamp Tax, so that that office may communicate the fact to the Principal Ad-

ministration of the Stamp Tax, within whose jurisdiction the mine may be comprehended. (R. L. imp., Art. 30.)

Permission is frequently obtained to pay mining taxes in Mexico City when it is not convenient to do so in the district in which the mine is located.

Every third-of-a-year's tax must be paid before the 31st of July, 30th of November and 31st of March of each year.

For said purpose the proper Administration, Principal or Subordinate, of the Stamp-Tax shall deliver to each interested party a schedule (*boleto*), which contains:

1. The name, "*Impuesto Minero*" (Mining Tax), at its head.
2. The name of the State and Municipality to which belongs the office that distributes the schedule.
3. The name of the mine, number of *pertenencias* on which the tax is to be paid, municipality in which the mine is located, name of the owner, company or enterprise which is in possession thereof, and the ordinal number of the register of the title-deed.
4. The amount of tax to be paid each third of a year.
5. Three blank columns destined to receive the revenue stamps corresponding to the thirds of a year, duly stamped.

The interested parties must be careful to fix the schedule referred to in a visible portion of the office of the concern. (R. L. imp., Art. 23.)

Duplicate schedules may be given out for the mining tax in case of loss of those which were given to the taxpayer at the time of the first payment. (Circ. Adm. Gen. Renta Timbre, November 30, 1897.)

Any mine owner may pay his annual tax in advance, if it suits his convenience so to do. (C. Hda., November 10, 1892, Sec. 7.)

All kinds of metallurgical works, including amalgamation-mills and smelters, are taxed as under Sect. XI. of this Synopsis.

POSTSCRIPT.

Secretary's Note.

It will be noticed that the foregoing paper has been copyrighted by the Institute. This has been done but once before, when the paper of Prof. Posepny on "The Genesis of Ore-Deposits" was similarly copyrighted. It is true that, according to Rule VII., "the copyright of all papers communicated to, and accepted

by, the Institute, shall be vested in it, unless otherwise agreed between the Council and the author." But this provision is intended mainly to secure to the Council the right to give permission for free republication, by technical periodicals, of any Institute paper, in whole or in part. This permission is given cordially; and duplicate blocks of illustrations are furnished at rates far below the original cost, to facilitate such republications—the desire of the Council being to increase in this way, as far as practicable, the circulation of each paper, and the consequent reward, in professional reputation, of its author. Hence the unnecessary formality of copyrighting each paper in the name of the Institute has been generally omitted.

The two exceptions to this practice were made to prevent republication in volumes issued for sale by enterprising publishers, and interfering directly with the sale of special volumes by the Institute.

In the case of Prof. Posepny's paper, the wisdom of this exceptional measure has been shown by the great demand for the first special "Posepny volume," and its greatly enlarged second edition. In the present case, the author is permitted to sell in the Republic of Mexico copies of his valuable compilation, in recognition of the generosity with which he has freely placed the result of his labors at the disposal of the Institute, which, for its own protection, as well as his, has formally copyrighted the "Synopsis."

Gems and Precious Stones of Mexico.

BY GEORGE FREDERICK KUNZ, NEW YORK CITY.

(Mexican Meeting, November, 1901.)

MEXICO has been famous for its silver-mines ever since the Spanish conquest; but in respect to gems, although many varieties occur, yet only a few have been obtained in any important amount. Considering the extent of country in Mexico and in the adjoining States of the Central American Republics, and the richness of mineral wealth that must surely exist there, our present knowledge of the occurrence of precious stones is remarkably small. The great prevalence of igneous rocks would lead us to anticipate the future discovery of many localities of gems and ornamental stones, when fuller scientific exploration shall have taken place.*

At the present time the only gem-stone that is systematically mined in Mexico is opal, and the only important ornamental stone is *tecali*, the so-called Mexican onyx. In addition to these may be mentioned the pink garnet, or rosolite, found in one

* See *Gems and Precious Stones of North America*. By George F. Kunz, New York, 1892, pp. 275–309.

locality in the State of Morelos, where it is worked to some extent, and the pyrope or Bohemian garnet, weathered out of igneous rocks, and gathered by the Comanche Indians in Chihuahua, as those of Arizona and New Mexico are collected by Navajoes. Other garnet-localities are known, but have not been developed. Topaz, which occurs in some places, will be mentioned later. Moreover, beautiful amethysts from Guanajuato are well known; but while making superb specimens for the mineral cabinet, they rarely afford material for cutting.

Great interest attaches to certain semi-precious stones, used and highly valued in pre-Columbian Aztec times, of which the localities have been lost, or but recently rediscovered. Prominent among these is the precious and even sacred *Chalchihuitl* of the Aztecs, at one time supposed to be turquoise, but now more correctly identified with jade. Recent studies of the sources of this remarkable stone are cited below. Another is a fine amethyst, different from that of Guanajuato, which was worked into ornaments by the ancient natives. A third stone, used to a great extent by the Aztecs, is obsidian, or volcanic glass. The wonderful chipping and lapidary skill shown in their work on this material in Mexico has never been equalled elsewhere. The principal locality where this obsidian was mined is known, and has recently been described in detail; but there were doubtless other localities, since there are several varieties of the product.

Of the rarer gems, diamonds, ruby, sapphire and emeralds, few occurrences are reported, and no deposits are mined; reliable information about them is limited. Santiago Ramirez, in a work on the minerals of Mexico,* relates, on the authority of another person, that in the Mexican war of independence, Gen. Vicenzo Guerrero, while selecting a camping-place for his men in the State which now bears his name, but at a point not named, found some diamonds. Their mode of occurrence, however, as described, makes it almost certain that they were only brilliant crystals of quartz. They are described as having been found loose in the interior of large hollow pebbles, and were, in other words, geodes. Some of them are said to have been set in earrings, and to have been pronounced octahedral diamonds; and others were purchased by a lapidary at the

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* *Noticia Historica de las Mineras de Mexico.*

capital. The accounts are vague; but one specimen, of three carats, is said to have been presented by Gen. Guerrero to the museum of the Mexican College of Mines. If this crystal could be found and identified, there would be a clear understanding of the facts.

Ruby has never been positively found, though it has been reported from Durango, and at one or two other points. It is not at all certain, however, that these specimens were not pyrope garnets. A single rolled pebble of blue and white mottled corundum is the nearest approach to sapphire yet obtained. It occurred among pebbles of agate and chalcedony, and was brought from near San Geronimo, Oaxaca, by Dr. Knight Neftel, of New York, and identified by the writer.

Emerald, or perhaps only a finely-colored beryl, is reported from three points—the hill of Cerro Gordo, in Guanajuato; Tejupilco, in the State of Hidalgo, near Tulancingo, where it is found in mica schist; and a locality in the State of Guerrero, from which a few small specimens of good color, but imperfect, are in the *Escuela Minera Nacional*, at the City of Mexico.

Garnet.—The occurrence of choice pyrope garnets in Chihuahua, near Lake Yaco, has already been mentioned. Fine ones are also reported from Sonora. They exist, doubtless, in many other localities in these portions of Mexico; for these garnets occur at various points in Arizona and New Mexico, and have been called "Arizona rubies." Another locality, at Triunfo, in Lower California, yields small bright crystals, evidently almandite, in a white granite. These are not pyrope, which occur in rounded nodular forms, in strictly igneous rocks. One or two other points are reported, but none of any importance.

Much the most interesting development of garnet in Mexico is at Xalostoc, in the State of Morelos.* Here the very perfect crystals have been found, dodecahedral in form, and up to a full inch in diameter. They are of a fine purplish pink color, embedded in a matrix of white limestone, with olive-green vesuvianite. Analysis proves these crystals to be a variety of grossularite; but their color is so peculiar among garnets that the name *rosolite* has been proposed, and to some extent adopted

* Carlos Sellerier on the "Minerals of Mexico," Buffalo, 1901.

for them. The crystals are not transparent, and hence are not suitable for cutting as gems, though very attractive as specimens. The white or pale-gray rock, however, studded with the embedded pink garnets and yellow-green vesuvianite, makes a beautiful ornamental stone, and has been employed as such. Polished slabs and small columns of this "rose-garnet" rock may be seen in the principal museums of the United States, notably a fireplace and mantel in the American Museum of Natural History, New York City.

Four species of the garnet-group have thus been definitely recognized from Mexico: pyrope, or Bohemian garnet; grossularite, in the pink variety just mentioned; essonite, or cinnamon garnet, described by Damour as occurring in light-red dodecahedral crystals in limestone; and almandite. Other members of the group undoubtedly occur, but have not been definitely determined, and no important localities are as yet known.

Topaz. — Topaz has been observed at many localities in Mexico, from Zacatecas all the way south to San Luis Potosi. In the Tepazon mountains, southwest of the latter place, and at the Hacienda Tepezate, at Pinos, seventy-five miles northwest of it, fine crystals have been obtained. They vary from colorless to rich wine-yellow, and from one to three inches in length, and are sometimes double-terminated, with brilliant faces. At these places they occur either in an eruptive rock of the rhyolite series, like that at Thomas mountain, in Utah, or in a kaolin, which is doubtless the same or a similar rock, in a soft decomposed condition. Specimens of great beauty in the Berlin Museum, presented by Dr. Soriano, of Mexico, are labeled as from one or two other points near San Luis Potosi—"Mesa de San José Buenavista" and "Mesa de Santa Cruz."

In Durango and Guanajuato, topaz occurs in its characteristic association with tin-ores. At Coneto, in the former State, it is abundant in connection with durangite and cassiterite, in the tin-bearing sands, resulting from the breaking-down of the trachyte rocks. The crystals are small, rarely over half an inch long, but brilliant, and of various tints, from colorless to yellow or pink red, and at times smoky black from included cassiterite. They are colored by tin in every case. At La Paz, in Guanajuato, large crystals, colorless or clouded, are found with tin-ore.

At some other Mexican localities, colorless topaz crystals have been observed containing inclusions of rutile. These colorless topazes are believed to be in all cases the result of a natural bleaching-process, in which the original tint, probably yellow, has been lost by exposure and weathering.

The Mexican topazes are familiar as mineralogical specimens, but it does not appear that any systematic attempt has been made to develop the localities with a view to their use as gems. So far as known, none of them would afford gems exceeding a few carats in weight.

Turquoise.—This stone, although much used and highly valued by the Aztecs, is not known to occur in the present territory of the Mexican Republic. Many objects of ancient work—carved, inlaid, or encrusted with turquoise—are found in Mexico, and it was doubtless one of several kinds of green stones included under the name of *chalchihuitl.* But all the true turquoise so used evidently came from the mines in New Mexico, Arizona and California, where there are abundant evidences of extensive ancient working. Yet it may have been obtained from some locality since forgotten, as the jadeite locality has been.*

The Quartz Gems.—Clear crystalline quartz, or rock-crystal, was used by the Aztecs in the manufacture of some remarkable carved objects—particularly crystal skulls, which have attracted much attention among archæologists; but where the material was obtained is not known. It is reported as occurring near Pachuca and Hidalgo, in the State of Michoacan, and in veins near La Paz, in Lower California. The center of the vein is said to be beautifully pellucid, while the sides are opaque white. It is possible, however, that the larger pieces used for the carvings may have been brought from the remarkable locality of transparent rock-crystal in Calaveras county, California. The largest skull shows inclusions of prochlorite in the quartz of which it is made, a feature which also characterizes the Calaveras quartz.

Examples of these rock-crystal skulls are to be seen in the Blake collection in the U. S. National Museum at Washington;

* The masks, daggers and encrusted human skulls are more fully described on later pages of this paper, and in the writer's work on *Gems and Precious Stones of North America,* already cited.

the collection of the late A. E. Douglas, in the American Museum of Natural History, New York city; and the Trocadéro Museum in Paris. The largest one, however, is now in the Archæological Department of the British Museum, for which it was secured by Sir John Evans, during his visit to the United States in 1897, by purchase from Messrs. Tiffany & Co. It weighs 175¼ Troy ounces and measures 210 millimeters ($8\frac{3}{16}$ in.) in length, 136 millimeters ($5\frac{3}{8}$ in.) in width, and 148 millimeters ($5\frac{11}{16}$ in.) in height. The eyes are deep hollows; the line separating the upper from the lower row of teeth has evidently been produced by a wheel made to revolve by a string held in the hand, or possibly by a string stretched across a bow, and is very characteristic of Mexican work. Little is known of its history and nothing of its origin. It was brought from Mexico by a Spanish officer, some time before the French occupation of Mexico, and was sold to an English collector, at whose death it passed into the hands of E. Boban, of Paris, and then became the property of Tiffany & Co. That such large articles of wrought rock-crystal are not to be found in Mexico might lead one to infer its possible Chinese or Japanese origin. But it is evident that the workmanship of the skull is not Chinese or Japanese, since, in that case, nature would have been more closely copied; while, if the work were of European origin, it would undoubtedly have been more carefully finished in some minor details.

Prof. Edward S. Morse, of Salem, Mass., who resided in Japan for several years, and Tatui Baba, of Japan, once of New York city, declare positively that this skull is not of Japanese origin. Mr. Baba gives as one reason for his belief, that the Japanese would never cut such an object as a skull from so precious a material.

In ancient Mexico there was undoubtedly a veneration for skulls, for we find not only small skulls of rock-crystal, but real skulls, notably the one in the Christy collection in the British Museum, encrusted with turquoise. It may have been one of these that suggested the making of this skull, the one at the Trocadéro Museum, and the smaller one.

Two very interesting quartz crescents are known: one in the Trocadéro Museum; the other in the collection of Prof. Maxwell Sommerville, in the Museum of the University of Pennsylva-

nia. Beads of this material are sometimes found in the tombs with jadeite and other stone beads. They rarely have a diameter of an inch.

Labrets (lip-ornaments) are occasionally found. But the wonderful crystal tablet now in the Field Columbian Museum, Chicago, is one of the most interesting and beautiful objects, made of Mexican rock-crystal, now in existence.

Among other varieties of quartz minerals, reference may be made to a prase or green quartz, which appears as a wrought material in some of the ancient articles of Aztec carving—notably a great votive adze in the British Museum collection, which has passed under the name of *chalchuit* or *chalchihuitl* or jade. The source of this material is not known; it may be beyond the Mexican boundary or in Central America.

The amethysts from the silver-mines of Guanajuato have a world-wide reputation. They are found in large quantities, associated with pink and white apophyllite, and ranging in color from the most delicate lilac to the deepest purple. The crystals are frequently light in color at the base, but very much darker at the terminations. Groups a foot across are often obtained, but not good enough to cut as gems. It is certain, also, that fine amethysts were formerly found at some other locality in Mexico; for collections, both in the United States and abroad, contain fine objects made by the Aztecs, but not at all resembling the Guanajuato mineral. They are deep purple, and more than 2 in. long, each being cut from a single crystal.

Chalcedony, agate, jasper, and the other varieties of quartz undoubtedly exist in abundance at many places in Mexico and Central America, judging from the numbers of objects, such as beads, figures and ornaments, shown in the collections. Some finely carved agate figures, 6 in. in length, are in the Blake collection in the United States Museum; and similar objects exist in the collections of other museums.

The name of "Cyclops" has been given to a peculiar occurrence of red and white chalcedony in concentric layers of concretionary growth, evidently from a solution, found in Chihuahua, about 1895, by Mr. E. J. Smith, of Chicago, who proposed the name. The specimens are, for the most part, small nodules, nearly hemispherical, and averaging half an inch in diameter. The center consists of a little nodule of red chalcedony, which

is overlaid and surrounded by clear colorless chalcedony. When the convex surface is polished *en cabochon*, the red center shows very strikingly, producing an eye-like effect; and the stones make attractive rings, scarf-pins and the like.

But it is the other species of silica, opal, that is by far the most important among Mexican gems, and the only one actually mined to any extent in the Republic. All the varieties of it are found both in Mexico and Central America; but the "noble opal" is more abundant in the latter than in the former country. The opal consists principally of silica, differing from quartz, however, in being never crystalline, and in containing from 3 to 12 parts of water in 100. The specific gravity of quartz is 2.65; of opal, about 2.2. Quartz has a hardness of 7, and opal of only 6, and even as low as 5.5.

Noble opal is the harder variety, in which the color is uniformly distributed, and ranges from opaque white to almost the pellucidity of glass. Fire-opal or girasol is the variety showing flashes of red and yellow, green and other colors, the opal itself ranging from colorless to white, transparent yellow, reddish brown to almost opaque. It is usually less hard than the noble opal. The names *lechosos* and *zeasite* are given by the Mexicans to the variety showing deep-green flashes of color. The name "harlequin" is applied to the variety in which the patches of color are small, angular, variously tinted, but evenly distributed. Common opal, so called, exhibits no play of color. This variety is found of many hues, chiefly, however, milky, pale green and rose-colored (when it is called quincite).

Hyalite, or Muller's glass, is a colorless, transparent, jelly-like variety, usually occurring in botryoidal masses. Semi-opal is an impure variety of opal. When opal is mingled with agate or jasper it is called opal-agate or opal-jasper; opalized wood is the name used when opal-silica, as a fossilizing agent, replaces wood; hydrophane is a variety that becomes transparent, and sometimes shows a play of colors, on being wet; and moss-opal is opal containing dendritic or moss-like markings, due to minute crystalline enclosures of oxide of manganese or of iron.

Opal is mined in a number of States of the Mexican Republic, notably in Queretaro, Hidalgo, Guerrero, Michoacan, Jalisco and San Luis Potosi. The most extensive and important are those in Queretaro, at and near La Esperanza; but those

at Zimapan, in Hidalgo, have been known for a much longer time. In Guerrero, the chief localities are at Huitzuco and San Nicolas del Oro, where the material is described as transparent, streaked with red, green and blue. Magnificent gems have been obtained from this State; and one opal mine-owner in Mexico is said to export thence from \$10,000 to \$12,000 worth yearly.

The Hidalgo opals have been referred to as the first that attracted extensive notice. Del Rio mentions that in 1802, in Zimapan, near the sanctuary of Guadalupe Hidalgo, hyacinth-red fire-opals were found in abundance in a red trachytic porphyry; the same variety is mentioned by Sonnenschmidt as occurring in the mine of Toliman, in a trachytic conglomerate. John Mawe, in his work on precious stones, published in 1812, mentions these opals as having been sent to England in quantities at that time. The fire-opal still occurs in its greatest perfection in the porphyritic rocks at Zimapan. It is generally of translucent hyacinth-red or topaz color, and sends forth gleams of fiery carmine-red, with more or less intense yellow and green reflections. When these opals are still in the compact red porphyry, they form objects of remarkable beauty, the flashes of red, green, yellow and blue color intermingling as the light falls on them. A beautiful opal from this locality, exhibited by the Mexican Commission at the Centennial Exposition at Philadelphia in 1876, was very greatly admired by visitors. Later, it went into the Leidy collection; then into the Lynde collection; and it is now in the Tiffany collection, Field Columbian Museum, Chicago.

An opal from Zimapan was analyzed by Klaproth, with the following results:

Silica,	92.00
Peroxide of iron,	0.25
Water,	7.75
Total,	100.00

The most extensive opal-mining, however, is in the State of Queretaro, where large quantities are produced and cut annually. The process of cutting is primitive and slow; but many opals are cut in a day upon common grindstones and polished upon wooden wheels, the stones being very soft. They vary

greatly in quality, and values range from 1 cent to $100 (Mexican) per specimen; $200, $500, and even $1000 has been paid for the finest found. The ordinary grades are very cheap, owing to the fact that they are either penetrated with cracks, or are liable to lose their color; nor are the stones of fine quality free from the risk of cracking, or of losing their play of color, especially after the lapse of time. But this subject will be considered more fully below.

In 1890, the writer visited the opal-mines of Esperanza, ten leagues northwest of San Juan del Rio, in Queretaro. They are very extensive, having been traced over a district thirty leagues long and twenty leagues wide. They were discovered in 1855, by a farm-laborer, on the landed estates on which they are situated; but it was 1870 before a settlement was made on the edge of the mountain Ceja de Leon, by José Maria Siurob, near the present mine of "Santa Maria Iris." In 1873, Dr. Mariano de la Barcena made a special report on this opal-district, in which he states that he has discovered ten veins, or "mines." He says:

> "The opals of Esperanza are found forming chains more or less regular, on the banks of porphyry in quartz, which forms its base, or disseminated through the mass of the same rock. Veins (*i.e.*, dikes) of porphyry are met with in regular banks, which in many cases preserve the same direction as on the hill of Ceja de Leon, southeast to northwest. The porphyry is a grayish-red color, . . . changing to reddish-white on the surface where it is altered. The aspect of the porphyry indicates generally the kind of opal it contains. Where the rock is brick-red in color, hard and compact, the varieties with a fiery-red color abound, also the tints combined with red, formed from different changeable colors, or rather a mixture of colors. Where the porphyry is paler and mottled, noble opals are found more abundantly, notably in the mines situated on the hill of Peineta."

These mines are remarkable for the richness and variety of their product. In a single piece of rock from the Simpatica mine, Dr. Barcena found four kinds—noble opal, fire-opal, harlequin and *lechosos*. Clear opals, with little fire, are abundant and cheap. The Jurado, the author found, had been excavated for some hundreds of feet in length and 100 ft. in width to 150 ft. in depth, at which level the porphyritic rock abounds in common opal and opal silica. The noble opals at Esperanza are remarkable for the extent and intensity of their reflections. The harlequin opals are noted for the diversity and the small

size of their colored spots, which resemble beautiful miniature mosaics. One of the most pleasing varieties has a play of red fire, like those from Zimapan, mingled with flashes of brilliant metallic emerald green, and occasionally a violet-blue of remarkable intensity. One of the red varieties from the Rosario mine, on the hill of Jurado, has a violet-blue reflection of peculiar beauty, and the same mine has produced a variety with a metallic emerald-green and a dark ultramarine color combined, or rather showing one after the other. The *lechosos* opals, as those with the red and green reflections are called in Mexico, are very common on the hill of Peineta, and less plentiful in the other mines of Queretaro. Other localities reported in the same State occur on the Batan, Gallindo and Lallare properties, in the district of Amealo. Those in the State of Guerrero have already been referred to. In San Luis Potosi, both common and fire-opal have been observed on the ridge of Mount Mezquitic, and at one or two other points.

Most of the cutting is done in the city of Queretaro, some 75 miles from the Esperanza mines. The miners receive an average of twenty-three cents per day for their labor. Thousands of opals are sold every year to visitors and tourists in the cities of Mexico and Queretaro, and at railroad stations in Mexico, New Mexico, Arizona and Texas, while many thousands of the poorer grade of handsome stones are exported to Germany, to be mounted in cheap jewelry. The poor stones often sell at from $1 to $10 a hundred.* Fine stones, rarely or never sold or even shown to tourists, sell for $10, $50, $100, or $500; and even $1000 has been paid for a single stone. Notwithstanding the great beauty of the Mexican stones, they suffer under two disadvantages. Much of the noble variety occurs only in thin layers, between or upon bands of common opal with little or no fire. Often half or two-thirds of a cavity containing this variety is filled with these layers or bands, like those in an agate, sometimes no thicker than a

* It is a frequent practice of dealers to keep poor opals immersed in oil and water for long periods, and to take them out only when a buyer presents himself. The temporary brilliancy and play of color, thus imparted, disappears with the evaporation of the absorbed moisture. Very poor opals are often soaked in oil, and then oil is burned on them. This causes them to crack and to absorb the burnt oil—the result being "black" opals, which possess enhanced brilliancy, but little strength or durability.

sheet of paper. Frequently the upper layer consists of hyalite, a colorless, jelly-like form, showing no play of color; or there is a brilliant but very thin layer of opal, not thick enough to be polished. These cavities often contain, also, circular crystals of rutile, which penetrate the opal; and this is possibly the coloring-matter of the yellow and red varieties.

The other disadvantage is the one already briefly mentioned, namely, a liability, real or supposed, to lose color, in a longer or shorter time, under conditions that are not well understood. In this respect the Mexican noble opals are inferior to those of Hungary and of Australia, which do not appear to have this defect. Although the reports are perhaps exaggerated, there is no doubt that such a loss does occur at times. It is specially noted in the colorless fire-opal variety (which seems to be as sensitive as it is gorgeous), and in the flame-opal; and it is frequent in the poorer and cracked varieties, which, for this reason, are sold very cheap. The report prepared by the Mexican Commission at the Paris Exposition of 1900 says that in 1891, at some localities not specified, in the States of Michoacan, Guerrero and Queretaro, opals of unusual hardness and notably free from this tendency were discovered. Such a discovery, if confirmed by further development, will have much interest, from both the scientific and the practical standpoint.

The whole subject of this loss of color, etc., long so perplexing, and of so much importance in connection with these beautiful gems, has resolved itself into the fact that opals containing from 5 to 10 per cent. of water (supersaturated silica, as it were) have gradually dried out and cracked. These were nearly always colorless, with large flames. In other varieties, containing 5 per cent. or less of water, this defect has rarely been manifested. The change sometimes occurs without apparent cause, and has been attributed to variations of the weather in temperature and moisture. But stones have been known to lose their brilliancy even when apparently removed from the influence of atmospheric changes, as when wrapped in paper and placed in a jeweler's safe or in a collector's cabinet.

Some years ago our late President and fellow-member, Prof. Egleston, the founder of the Columbia School of Mines, and recognized as an expert collector and judge of minerals and

gems, possessed a small glass bottle, filled with cut opals of extreme beauty. He said that they had been given to him by a prominent jewelry firm in New York as entirely worthless, having completely lost their color; that he took them as specimens simply, and placed them in his cabinet, where, after awhile, they had recovered all their former brilliancy and fire. The only explanation that he could suggest was that the basement-room in which his cabinet stood might have been somewhat more damp than the store from which the opals had been brought. It is certain, however, that the room was not so damp as to render it unpleasant or unsafe; and the change as to moisture must have been but slight. It would be interesting to know what was the subsequent behavior of the same stones; but on this point we have no information. Keeping opals in oil prevents their cracking by preventing their drying.

Probably the widespread superstition which once prevailed, but has now almost, if not entirely, disappeared, as to the opal being an "unlucky" stone, may have originated from circumstances of this kind.

On the other hand, many opals are as enduring as could be desired. Perhaps the most celebrated Mexican opal is the one sold some years ago in the collection of the late Philip Henry Hope, now in the Tiffany collection, Higinbotham Hall, Field Columbian Museum, Chicago. It is a fire-opal, or "sun-opal," carved with the head of the Mexican sun-god, and is believed to have been taken from a temple. It has been known since the sixteenth century, and brought £262 sterling at the sale of the Hope jewels in London in 1886.* A remarkable fire-opal, brought from Mexico by Alexander von Humboldt, is preserved in the Mineralogical Museum at Berlin. In these notable instances, as in countless others, there seems to have been no deterioration.

The Spanish historians, in their marvelous tales of the wonders seen in Mexico at the time of the Conquest, describe the image of the mystic deity, Quetzalcoatl—god of the air—on the great pyramid of Cholula, as wearing a "mitre" or head-dress waving with plumes of fire. This effect is supposed to have been produced by masses of mosaics of fire-opal. The concep-

* Catalogue, Hope Collection, pl. xxxi., Fig. 3, p. 3. London, 1839.

tion is splendid, and as characteristic of Aztec art as the marvelous golden image of the sun, encrusted with "emeralds" (evidently green jadeite), facing and reflecting the morning rays on the wall of the temple of the sun at Cuzco, was characteristic of the Inca art of Peru.

Beautiful exhibits of Mexican opals have been made at the recent World's Fairs, from the time of the Centennial down to the present. At the Paris Exposition of 1889, the fire-opals and noble opals shown by the Mexican Commission—particularly one large specimen with superb pink flame—attracted much attention. One very remarkable specimen from the Iris mine, Queretaro, has been described by the writer. It was a nodular mass, as large as a hen's egg, of fire-opal, in trachyte, and was penetrated by yellow, polished and iridescent acicular crystals. It is not certain what these were, but they were apparently rutile. The specimen is in the Harvard University collection.

Some of the mixed varieties of Mexican opal, although not suitable for cutting into gems, have fine possibilities as ornamental materials of great elegance. Such is a beautiful variety of opal-agate, found in the State of Jalisco, in which pink, yellow and green, especially of the softer shades, occur together, blended and veined in the most pleasing manner. It exists in considerable quantity, and is valued as a decorative stone for metal-work or jewelry.

Chalchihuitl was the name, celebrated in Mexican archæology, applied to certain green stones, capable of high polish, which were carved into various ornamental forms, and very highly valued. There has been much mystery and much discussion as to what this precious material really was, and whence it was obtained. It seems evident that several minerals were included under this name—among them a green quartz or prase, some of the deeper green varieties of *tecalo* or Mexican onyx (so-called), and probably turquoise; but the precious *chalchihuitl* has now been proved to be jadeite, a stone which has possessed a singular charm for many aboriginal peoples in widely separated parts of the globe, but which, for some reason, has not so much attracted the notice or the taste of the "historic races."

When attention began to be drawn, some thirty years ago, to the turquoise mines near Santa Fé, New Mexico, the eminent

geologist and explorer, Prof. William P. Blake, noting the evidences of ancient workings at those mines, and the traditions still preserved among the native tribes of the region as to the sacredness of the stone and its association with Montezuma, felt assured that here was the solution of the *chalchihuitl* mystery. The stone must be no other than turquoise; and here were the evidences of its long-lost source. At first sight this view was highly satisfactory, and it was widely accepted; but later investigation has not confirmed it, except in part. Two objections are conclusive: (1) that turquoise never occurs in masses of sufficient size to make objects like many of the *chalchihuitls ;* (2) that the ancient Mexican tribute-rolls distinctly show that *chalchihuitl* was a product of southern Mexico—the region between the capital and Central America. To set at rest all questioning, moreover, chemical analysis proves that the real *chalchihuitl* is not turquoise, but jade.

Under the name jade, however, are included two minerals, nephrite and jadeite, closely similar in appearance and properties, which were separated by Damour in 1865. Jadeite is a silicate of alumina and soda, classed in the pyroxene group by mineralogists, while nephrite is a variety of amphibole or hornblende, a silicate of alumina, lime and magnesia.

In Mexico and Central America jadeite only is found, not nephrite, while among the jades of the northwest coast of America and Siberia, in New Zealand and Oceanica, jadeite has not yet been recognized. The Mexican jadeite has been treated of by Damour;* and a number of specimens in the United States National Museum have been described by Clarke and Merrill in their article "On Nephrite and Jadeite."† These specimens vary widely in color, from light to dark and from dull to bright greens (some plain and some mottled), and from translucent to opaque, but agree closely in their specific gravities, which were carefully taken by Dr. William Hallock, and are all above 3. Those that were analyzed gave very nearly the regular composition of jadeite, a silicate of alumina and soda.

The Central America series of jades in the same collection are mostly from Costa Rica, with some from Guatemala and

* *Bull. Société Mineralogique*, iv., 157.

† *Proc. U. S. Nat. Museum*, xi., 1888, pp. 121–125.

Nicaragua. They also are principally true jadeite, with density above 3; though some appear to be green quartz (resembling prase), and others, of much less hardness and density, are indeterminate minerals of various kinds. No nephrite is recognized among them. The same variations in color, etc., appear in these as in the Mexican jadeites.

In thin sections under the microscope the jadeites present a distinctly crystalline, or granular-crystalline, texture, in which sometimes the cleavages, and even the crystal-angles, can be recognized: from these the pyroxene character of the mineral is definitely traceable. The nephrite jades, on the other hand, show a minutely fibrous, scaly and lamellar structure when magnified. There are, however, intervening types; and the structure alone may not in every instance be relied upon to distinguish the two species.

Nephrite is in some cases a secondary mineral, arising from the alteration of pyroxenes into hornblendes (the change called uralitization); and hence, as Clarke and Merrill suggest,* it may be well said that a "true nephrite may grade into a granular diopside rock resembling jadeite," according as the change has advanced more or less. But the density of nephrite is always below 3, and that of jadeite always above 3.

The name jade is from the Spanish *piedra de hijada*, or "stone of the loins"; it is first mentioned under this name in the writings of Monardas in 1565, and had been brought from Mexico and Peru with this designation, arising from its supposed efficacy in diseases of the loins and kidneys. This idea entered into all the nomenclature of these allied stones; the Spanish term was used in its Latin form, *lapis nephriticus*, by Clutius in 1627; Linnaeus called it *talcum nephriticum* in 1768; and Werner gave it the mineralogical form *nephrit* in 1780. The Germans named it *Nierenstein* and *Beilstein;* the French, *pierre néphrétique*, with other familiar variations.

It is evident that the *chalchihuitl* stone was highly prized among the natives in various ways. Besides its reputation for curative or preventive power against certain forms of disease, it was valued for its beauty of color in the finer varieties, and was carved into objects of ornament. It seems also to have

* *Loc. cit.*, p. 129.

possessed some kind of mystic sacredness, religious or ancestral, like that attached to turquoise by the traditions of Montezuma and the ancient turquoise mines, which still linger among the native tribes of New Mexico and Arizona. How far these ideas were blended, or what connection existed between them, it is impossible to determine. The curative powers may have been ascribed to some deity to whom the stone was sacred, and the wearing of beads or of carved amulets may have been partly religious and partly sanitary in motive, while finer specimens and rarer varieties may have been reserved as the special prerogative of royal or sacerdotal chieftains, and worn as insignia of exalted rank.

When we consider how superstitious were the Europeans of the 16th and 17th centuries, it seems also possible the voyagers, adventurers and sailors who brought home the jadeite as loot, originated its supposed virtues in their fertile brains, to enhance its value for gift or for sale, even though the natives never attached such properties to the mineral.

Many specimens of carved jades were brought over early to Spain; but it is probable that the most remarkable were lost. Wonderful tales were told of the carved articles of "emerald" belonging to Montezuma, including a goblet and a "rose," which were shipped by Cortez to the King of Spain, among the choicest treasures of the conquest. Unfortunately the vessel that bore them foundered at sea, and these unique works were forever lost. It is impossible that they can really have been of emerald, as that gem scarcely occurs in Mexico at all. They were probably *chalchihuitls* of peculiar richness of color, and constituting, doubtless, both in material and in workmanship, the finest products of Aztec art.

The most remarkable specimens now known of jadeite from Mexico are chiefly carved masks or pendants or celts or adzes, these latter also being often carved and elaborately ornamented, showing that they were insignia of rank, and. not implements for use. Many of them retain on the back or sides portions of original rounded surfaces, proving that they were made from boulders. In several instances, large pieces have been reduced by cutting out smaller portions from the back, leaving the carved face uninjured—thus indicating either increasing scarcity of high-priced material, which induced the removal of su-

perfluous portions to make new objects, or perhaps some peculiar tradition or superstition, attributing special sacredness to pieces once belonging to some deceased chieftain, which might be perpetuated to his successors by bestowing on them parts thereof, while the main original was buried with its possessor.

The "Kunz" jadeite adze in the American Museum of Natural History, New York City, which has been described by the writer, is believed to be the largest known. On its face is carved a grotesque human figure; and, for so hard a material, the workmanship is excellent. It is said to have been found about 1869, in Oaxaca. It measures 272 mm. (10.13 in.) in length, 153 mm. (6 in.) in width, and 118 mm. (4.63 in.) in thickness, and weighs 229.3 Troy ounces. Across the ears it is 153 mm. (6 in.); across the lower axe-end, 82 mm. (3.25 in.); the height of the head down to the neck is 158 mm. (6.25 in.); the height from chin to foot, 115 mm. (4.5 in.), and the length of the legs 50 mm. (2 in.). From the back a piece about 160 mm. (6.5 in.) long and 50 mm. (2 in.) wide has been removed.

The color is light grayish green with a tinge of blue, and streaks of almost emerald-green on the back. In style of ornamentation it very closely resembles a gigantic adze of granite, 57 centim. long and 34 wide, mentioned by A. Chavero; and it has almost a counterpart in a green aventurine quartz adze, now forming part of the Christy collection at the British Museum, and formerly in the possession of Percy Doyle, Esq., of the British diplomatic service. It differs from these two objects, however, in having no ornamentation on the forehead, and in having four dull markings on each ear, one under each eye, and one near each hand, which seemingly could have served no other purpose than to hold thin plates or films of gold, which the polished surfaces would not do. If this was so, no trace of the gold can now be seen. From all appearances, this adze was shaped from a boulder, since weathered surfaces, such as appear on all sides of it, would be found only on an exposed fragment. The dull markings show a tiger's or serpent's head on the brightly polished human face. The lapidarian work on this piece is probably equal to anything that has been found, and the polish is as fine as that of modern times.

A feature of great interest is the removal from the back of

two portions, which must have weighed fully 2 lbs. Why was this done? Similar removals and divisions have been mentioned in other cases. In a paper read April 27, 1881, before the American Antiquarian Society, Philip J. J. Valentini described two carved jadeites which showed similar treatment. One was the Humboldt celt, a votive adze presented to Humboldt by Del Rio in 1803, and the other the so-called Leyden plate, which was found by S. A. von Braam near San Félipe, in Honduras, near the borders of Guatemala, and given by him to the Leyden museum. These objects are 9 in. long and 3.25 broad; the former being 1.4 in. and the latter 0.6 in. thick. (The fact that the two, if placed together, face to face, correspond exactly in outline, makes it highly probable that they were originally part of one and the same celt; and it is quite possible that the remaining parts may yet be found.) In 1886 Professor Frederick W. Putnam exhibited before the same society a remarkable series of Nicaraguan and Costa Rican jadeites, which were all ornaments, and showed that they had been made by cutting celts, which had been perforated by one or two drilled holes, into halves, thirds and quarters. In one instance two of them fitted together. The explanation suggested was that, the supply of the material having become exhausted, recourse was had to division, or the removal of a part from existing articles for the purpose of making others, perhaps to be buried with some dead chief, or to be bestowed as sacred treasures on new branches of the tribe.

Fully one-eighth has been thus removed from the back of this adze; and the manner in which the instrument used in its removal was held has produced a rounded cut on each side, lending probability to the supposition that some abrasive was employed, drawn with a string held in the hands, or stretched across a bow. If the Aztecs knew of the existence of corundum, we can better understand how they worked so large a mass of tough and hard material. But corundum is hardly known in Mexico; and it may be remembered that the New Zealand Maoris cut and carved their jade articles by means of thin slabs of hard, gritty, fine-grained sandstone.

So far as the writer has been able to learn, no similar object of equal magnitude and archæological interest exists. The next most important specimen is a large jadeite celt, described

by Dr. A. B. Meyer as belonging to the Royal Ethnological Museum at Dresden. This, however, weighs only 7 lbs., and is wholly devoid of ornamentation. Nor will the Humboldt celt or the Leyden plate, above referred to, compare with it at all.

Various other jadeite articles of similar character have been exhibited and described, but many of them, like some of those already referred to, belong rather to Central America than to Mexico, or else are of uncertain locality. Among the latter is a curious little mask, apparently representing the face of a crying child, exhibited in 1879 before the American Association for the Advancement of Science by the late Mrs. Erminnie A. Smith,* noted for her studies in American ethnology.

The late Mr. George Squier, the eminent archæologist, possessed a number of finely carved *chalchihuitls*,† which he described and figured. Several of these were very brilliant in color, and might have been regarded by unskilled persons as carved, like the reputed treasures of Montezuma already mentioned, from opaque emerald. To a considerable extent, moreover, they bore Maya, rather than Aztec, symbols.

It seems that the veneration of *chalchihuitls* extended through all Mexico, and Central America as well. The question, whence the material was obtained, is of great interest to archæologists; and its solution might bring into notice a beautiful ornamental stone for modern uses. As already remarked, jade has been prized and elaborately worked by many semi-civilized peoples, but never, until recent times, employed by the historic races. Yet its fine texture, its hardness, and the beautiful polish which it takes and retains, combined with its rich and delicate tints, and its translucency, render it a material of great possibilities. Only within a few years has the first attempt been made to utilize jade as a "civilized" ornamental stone. This was done at the Paris Expositions of 1878, 1889 and 1900, in the remarkable exhibit of Siberian nephrite made by the noted Russian explorer, M. Alibert.‡ The display was one of extreme beauty

* *Proc. Am. Assoc. Adv. Science*, 1879, vol. xxviii., p. 523.

† Now in the Squier collection, at the American Museum of Natural History, New York city.

‡ The writer saw at the Imperial Lapidary Works, at Peterhoff, Russia, a canopy of jade (nephrite) 15 ft. high, that was being made for Alexander III.

and interest, and showed that this stone was abundantly capable, at the hands of European artists, of yielding the finest results, equalling or surpassing the long-celebrated Chinese work. If the locality of the rich green *chalchihuitls* of Mexico and Central America could be found, and the material could be obtained in any useful quantity, it would be a beautiful addition to our ornamental stones, as well as an interesting discovery from the standpoint of science.

It is to be hoped that before many years this problem may be solved. Much of the carved Mexican material was evidently obtained from boulders and rolled pieces, carried down by streams from unknown localities in the mountains. But, in some instances, it seems that the ancient Mexicans must have known the mineral in place.

The whole situation is curiously parallel to that of the "oceanic jade" of New Zealand, where that substance, so much prized and venerated, was derived almost entirely from boulders in certain streams, and the actual places of occurrence were unknown, save perhaps as a secret to a very few.

A valuable and important paper has been published during the past year by the well-known archæologist, Mrs. Zelia Nuttall, embodying the results of an extended investigation as to the probable sources of the jadeite, which appears so prominently in early Mexican documents. The chronicle of Tezozomoc relates the conquest of the southern tribes of Mexico by Ahuitzotl in 1497, and the terms granted by him to them, which comprised various forms of tribute—gold, skins, plumage and precious stones—first among which was named *chalchihuitl*, of all varieties. Twenty-two years later, at the time of the Spanish invasion, the tribute-roll of Montezuma gave full lists of towns from which *chalchihuitl* was sent to the capital. A copy of this celebrated tribute-roll, sent by Cortez to Charles V., shows that a large number of places in the region of Ahuitzotl's victories, in southwestern Mexico, had continued this tribute down to Montezuma's time, as had been done also by a number of other localities, not so near to the region named.

Mrs. Nuttall undertook, by a close examination of these ancient lists of towns, to identify them, as far as possible, with existing localities. The lapse of four centuries, and the replacement of native by Spanish names, might seem to render this

attempt well-nigh hopeless. But it is surprising how large a proportion of them are clearly recognizable—sometimes modified, but often almost unchanged. Others, not yet identified, may possibly be traced hereafter by more minute local investigation. Mrs. Nuttall has employed the best and latest maps, and has carefully excluded all identifications that were at all doubtful.

On grouping these localities and studying their relation, they arranged themselves in an interesting manner. They all belong to a region extending from the Isthmus of Tehuantepec, the scene of Ahuitzotl's victories, southeastward through the State of Chiapas to the Pacific Ocean and the border of Guatemala, and northwestward through the four States of Vera Cruz, Puebla, Oaxaca and Guerrero—the last three representing the native province of Mixtecapan.

Tables of the ancient and modern names are given by districts, accompanied by maps on which the identified points are marked. These very interesting maps show that the precious mineral was obtained at numerous places throughout a wide region. For the determination of actual sources, however, with a view to their rediscovery, the facts elicited are perplexing, from their very abundance. But there are some special indications that may well be followed up.

In Chiapas, 9 towns appear in Montezuma's roll. Six of these are clearly identified, lying near the Pacific coast in the angle between it and the Guatemala line. A town inland, considerably northward of this group, and not named in the tribute-roll, bears to this day the name of Chalchihuitlan—the "land of *chalchihuitl.*" This region was not subdued by Ahuitzotl's conquest of Tehuantepec, and required a second expedition to reduce it; but it finally became tributary on the same terms as the others. Here is apparently one district where the mineral could be found by sufficient search.

In the State of Oaxaca, or on the adjacent border of Vera Cruz, fifteen points are identified out of twenty-two in Montezuma's list. Six are identified in points in Vera Cruz; with 6 others uncertain, but evidently not far distant. Several of these are near the Gulf coast and north of the latitude of Mexico City. Proceeding thence inland, the map of the State of Pueblo shows no less than 23 places identified. Two or three are in the north-

ern and southern portions of the State respectively, but most of them are grouped along the central zone lying between Orizaba on the east and Popocatepetl on the west, though tending rather southward of the latter, and passing over into the State of Guerrero, where 6 towns are grouped in the northeastern portion. The center of this group of localities would lie on a meridian line passing through the City of Mexico, about half-way between that city and the Pacific. This would appear to be another well-defined region where *chalchihuitl* must have occurred in place.

The Guerrero localities are inland. None are noted in the coast-region. There are two quite near the coast in Oaxaca, west of the Bay of Tehuantepec; and the coast-group in Chiapas, already mentioned, lies southeast of that bay, suggesting a line of occurrences along the Pacific, interrupted by the depression of the bay.

Mrs. Nuttall gives, in conclusion, a further list of those names of places in Mexico which apparently involve or include the word *chalchihuitl.* While these are suggestive and interesting, they may not all be important; but the name *Sierra de Chalchihuites*, given to a small range of mountains in the State of Zacatecas, near Sombrerete, and that of a mining town called *Chalchihuites*, at the northern end of the same range, certainly offer striking intimations.

This investigation is highly creditable to Mrs. Nuttall, and will undoubtedly stimulate and direct the search for jadeite, which evidently must occur at numerous points in Mexico, anciently familiar, but long forgotten and lost. Full geological investigation of the nature and distribution of the abundant crystalline rocks is the great desideratum for an intelligent further pursuit of this interesting inquiry.

A point not alluded to by Mrs. Nuttall, yet nevertheless of much significance, is the kind of material called for as tribute from four different sections: *i.e.*, whether "beads," that is, pebbles and rolled pieces, or larger single pieces, are specified. This point was noted twelve years ago by that eminent archæologist, the late Dr. D. G. Brinton, in discussing the tribute-roll in the *Codex Mendoza*, published in Lord Kingsborough's "Antiquities of Mexico" (London, 1830). Examination showed that all the lists given in Mrs. Nuttall's paper called

for strings of *chalchihuitl beads* (one to five every six months), except in one section, where "three large pieces" were also required. The map shows that half or more of the identified localities in this section were grouped along the border of Oaxaca and Vera Cruz, about equally distributed on either side. Here is a well-defined region, southeast of the City of Mexico, and not far from Vera Cruz, in which the mineral must certainly exist in place. Other localities, from which only "beads" were called for, were plainly along water-courses, where rolled pieces alone were found. In these cases the material may yet be traced up-stream to the sources whence it was brought down by natural agencies; but these places were evidently unknown to the natives, then as now.

The region along the Oaxaca-Vera Cruz border, on the other hand, yielded larger pieces, doubtless from an actual occurrence in place.

It is interesting to observe how closely the studies of Mrs. Nuttall, read with this clue, support the suggestions of Dr. Brinton as to the most promising region for search. The *Codex Mendoza* calls for pieces, three every year, in addition to beads, usually from Tototepec, Chinantlan, and some other towns in Oaxaca, principally in the department of Vilalta, a region described as wild and mountainous, inhabited by the Mixe Indians and the Chinantecas.* Dr. Brinton suggested that this district of Vilalta was the most promising in which to seek for jadeite in large pieces, or perhaps actually in place.

It may be added here that there is in the writer's possession a rough piece of Mexican jadeite, fractured and sawed, not rolled, although it may have been broken from a boulder.

From the abundance of Central American specimens, it is apparent also that other *chalchihuitl* localities must exist, probably all the way south to Costa Rica.

Some eminent students of archæology have been inclined to believe that the jadeite objects found in the New World were not indigenous, but had been brought from Asia, where jade has been known, valued and wrought, from very ancient times. On this theory, supported by the supposed similarity between the Mayas and the ancient Burmese, the articles became evi-

* *Science*, vol. xii., p. 168, Oct., 1888.

dences of the Asiatic origin of the American peoples, or at least of trans-Pacific communication and commerce. The chief exponent of this theory was the late Dr. Heinrich Fischer, of Freiburg, Baden, who devoted years to the study of the subject.* The grounds for it, however, were slight; the main one being the fact that jade had long been familiar in eastern Asia, and had not been previously known in America. Stress was laid on the removal of portions of large objects to make smaller ones, as though the precious material was very limited in amount, and becoming exhausted; but it is not certain that this was the real reason for this practice. As noted above, it may have been entirely different, and connected with some religious or ancestral tradition. Another argument was that the green jadeite of Burma, if heated,† assumes a brownish cast, such as appears in some American examples, presumably also from heating. But this is merely a presumption; and the fact that the green color of many silicates is due to protoxide of iron, which is altered to sesquioxide by heat, and then becomes brown, are enough to dispose of this scanty foundation for so important a theory.

In the same way the nephrite jade of Alaska was at first attributed to Siberian sources; but some years ago it was definitely determined to be of American origin.

On the other hand, Dr. A. B. Meyer, Director of the Ethnological Museum at Dresden, and other foreign students of the subject, opposed the views of Fischer, and argued from various premises for the indigenous character of the American jadeite.

More recently, the whole subject has been very thoroughly reviewed by Professors F. W. Clarke and George P. Merrill, of the United States National Museum.‡ The great collection of that museum contains a fine series of jadeite objects from Mexico, mostly from the State of Oaxaca, together with a number from Central America, the choicest of which are from Costa Rica. In summing up their conclusions, these writers find that the articles probably came from a number of locali-

* Muhlenpfordt, *Schilderung der Republik Mexico*, vol. ii., p. 213.

† In Burma, jadeite is mined by "fire-setting;" and in New Mexico turquoise was mined in the same way.

‡ "On Nephrite and Jadeite," *Proc. U. S. Nat. Museum*, vol. xl. (1888), p. 115.

ties, and are of no value whatever in tracing the migrations or the intercourse of races; that these minerals are not uncommon in metamorphic rocks, and hence are liable to occur wherever such rocks abound; so that their presence has no more significance as to tribal movements or aboriginal trade than pieces of graphite would have. The natives required and valued a hard, tough mineral, capable of receiving and retaining a sharp edge for adzes or celts, or a high polish for ornaments; and they utilized it wherever it was found.

As to the various stones included under the name of *chalchihuitl*, the following points may be noted in concluding this discussion:

The identity of jade with *chalchihuitl* was first suggested in 1866 by Prof. Raphael Pumpelly, in his "Geological Researches in China."* In 1883, as already noted, Prof. William P. Blake† had identified *chalchihuitl* with the New Mexican turquoise, and proposed the mineralogical name *chalchihuitl* for the bluish-green variety. Certain it is, however, that although turquoise was doubtless included under *chalchihuitl*, and, perhaps, was regarded as a specially choice variety, it formed but a part of the material so designated by the Aztecs. The turquoise is never found in pieces of large size; it was used in the form of small beads, usually cylindrical, and for inlaying and encrusting various ornaments. In some cases skulls‡ are thus overlaid with a sort of mosaic pavement of turquoise. Such specimens may be seen in the British and Vatican museums in Europe, as well as masks and small animal figures. The early Spanish writers of the time of the Conquest refer frequently to turquoise, and identify it with *chalchihuitl* as a material greatly valued by the natives. Some of the presents made of this material, and sent by Montezuma, through Cortez, to the Emperor Charles V., are believed to be now among the crown-jewels of Spain. Coronado, in 1540 and 1541, and Friar Marco de Nica, who traveled through New Mexico in 1539, made frequent references to turquoise. It is said that the insurrection of the natives which led to the driving out of the Spaniards in 1556 was caused by their resistance to forced labor in the turquoise-mines.

* *Smithsonian Contributions*, xv., 118.

† *Am. Jour. Sci.*, 2d ser., xxv., 227, 1858; 3d ser., xxv., 197, 1883.

‡ *Am. Jour. Sci.*, 2d ser., xxv., 227, 1858; x3d ser., xv., 197, 1883.

The fact seems to be that the *chalchihuitl* so highly prized was jadeite in southern Mexico and Central America, and turquoise in northern Mexico and New Mexico. Each species is a green mineral, and was greatly valued, and made a matter of tribute to the crown; but the jadeite, as we have seen, is confined to the region south of the capital, while the turquoise is unknown there, but occurs at a number of localities in the territory acquired by the United States after the Mexican war. Not only the mines at Los Cerrillos, near Santa Fé, but every other locality discovered (and there are now a number), bear conspicuous traces of long and laborious working, in ancient times, by the crude methods of stone tools and fire, which the writer observed at Los Cerrillos.* It is thus abundantly proved that the turquoise was highly valued and largely used.

On the other hand, the evidence that the *chalchihuitl* of southern Mexico was jadeite has already been sufficiently dwelt upon. Nowhere, indeed, was this mineral regularly mined, like the turquoise of the northern region. Most of the material produced consisted of rolled boulders; and although, as we have seen, the exceptional requirement, for tribute, of pieces, in distinction from beads (*i.e.*, pebbles and boulders), points to a district on the border of Oaxaca and Vera Cruz, where it must probably have been found in place, the actual localities of such occurrence were generally unknown.

Other minerals, similarly used and designated, were: a green quartz, or prase; a variety of lamellar serpentine; some of the richer colored kinds of *tecali*, or Mexican onyx; and occasional undetermined materials of greenish color. It does not appear that the ancient Mexicans knew either malachite or chrysocolla, which would have made *chalchihuitls* of surpassing elegance. Had they discovered these beautiful minerals in copper-mines like the Globe and Copper Queen of Arizona, which have yielded such magnificent specimens, they would have prized them above anything that they possessed, and would have carved them into objects of regal treasure.

Friar Bernardino de Sahagun, in his *Historia de Neuva España* (lib. ii., chap. 8), says that *chalchihuitl* was a general term for choice green stones in one of the *nahuatl* (Mexican) languages.

* See *Gems and Precious Stones of North America*, pp. 63–65.

Any such mineral, somewhat translucent, and capable of taking a high polish, was highly esteemed. He gives the following varieties, distinguished by descriptive adjectives, in the native speech :

Iztac chalchihuitl (white *chalchihuitl*), of a fine green, quite translucent, without stripes or stains.

Quetzal chalchihuitl (*precious chalchihuitl*) : white, with much transparency, and a slight greenish tinge, somewhat like jasper.

Tlilavotic, literally " of a blackish watery color " ; with mingled shades of green and black, partially transparent.

Tolteca-iztli, literally " Toltec knife " or " Toltec obsidian " ; of a clear, translucent green, and very beautiful.

It is evident that the first is the so-called Mexican onyx, or Tecali marble, which exists in Tecali in veins, and is in reality an aragonite stalagmite. Great quantities of it were made into figures, ornaments, and beads, which are found all the way from northern Mexico down to Oaxaca. This so-called onyx is extensively quarried to this day, forming one of the richest ornamental stones (see *Mexican Onyx*, above).

Various green stones known at present were used in considerable abundance in ancient Mexico. Among eight green objects, sent to the writer at one time as jadeite, four were jadeite ; one was laminated serpentine ; another, a greenish quartz ; and two a mixture of white feldspar and green hornblende. In a string of beads there were four pieces of true jadeite ; but all the others were, like the jadeite beads, simply rounded pebbles, drilled from both sides ; and there were nearly a dozen different substances in this string. The question is, were such pebbles a part of the tribute mentioned in the *Codex Mendoza?* Similar strings of pale green pebble-beads were exhibited under the name of jadeite in the Blake collection in the Mexican section of the Department of Ethnology, at the Buffalo Pan-American Exposition of 1901.

This confusion is not surprising. While no nation has used jade more extensively and for a greater period than the Chinese, yet it was only in 1865 that Damour isolated jadeite and nephrite as two forms of jade, and, still later, chloromelanite from jadeite, as a variety containing more iron and heavier in specific gravity. The Chinese experts and art-lovers are often

mistaken; and a variety of green and white tough stones, such as light green and dark green prase, bowenite, fibrolite, quartzite, and others, have been, and are still, mistaken by them for jade. It was only when exact scientific investigation came into play that the true facts about many supposed valuable pieces were known. But, on the other hand, it is surprising how the Chinese, the Swiss lake-dwellers and the ancient Mexicans, recognized correctly the water-worn, iron-stained and apparently unrecognizable pebbles as jade or jadeite, whether they were selected for an art object, a celt or tool, or for an ornament.

Obsidian.—Strictly speaking, obsidian, or volcanic glass, could scarcely be considered as a precious stone; yet in Mexico it has been used in so many ways, has been so beautifully worked, that to omit it from this paper would be to ignore an ornamental material which figured more largely in ancient Mexican art than even jadeite.

This mineral, frequently found in connection with volcanoes and igneous outflows, is not a distinct species, but a peculiar glassy and non-crystalline form, assumed by several varieties of igneous rocks, rapidly cooled from the molten state. In such conditions, it seems that there has not been time for the process of crystallization to take place, and the result is this glassy modification. The same thing is often seen in furnace-slags.

The name is a *nahuatl* (aboriginal Mexican) one; and the substance is abundant at various points in Mexico and the western United States—for instance, at the "obsidian cliff," a marked feature in the Yellowstone Park, and many localities in California, Nevada, and the Gila region in Arizona. It was a favorite stone among the Aztecs, and was mined extensively in Mexico for a great many purposes, both useful and ornamental. It could be "flaked" into knives and many other implements, with sharp cutting edges; and it could also be brilliantly polished. The knives used by the Aztec priests in their terrible rites of human sacrifice at the pyramids of the Sun and Moon at San Juan Teotihuacan, a short distance from the City of Mexico, were keen-edged obsidian flakes, of which great quantities are found near these pyramids. Similar implements, fragments, and the "cores" that were left when a mass

had been flaked down as far as practicable, are abundant throughout Mexico, especially around ancient village-sites, and may be seen in almost any archæological collection.

Obsidian is generally velvety black, but varies to gray, and sometimes presents reflections of different tints—reddish-greenish, bluish, silvery or golden. It frequently contains multitudes of minute crystals, which yield these various reflections; and then the mineral may present a double color, black in one direction and golden *chatoyant* in another, usually at right angles to the black; giving, when properly cut, a "cat's-eye" effect, and forming the "obsidian cat's-eye."

It occurs at many Mexican localities, such as Tulanango, in the State of Hidalgo; near the village of Magdalena, in Jalisco; at Cadereita Mendez, in Queretaro; at Ucareo, Benjamo; and on the Pateo property, in Michoacan. But the chief locality, noted for its extensive ancient mines, is the Cerro de Navajas, or "Hill of Knives," on the Guajalate estate, near Pachuca, in the State of Hidalgo, northeast from Mexico City. This was the principal source of the material so largely employed for knives, arrow-points, spear-heads, masks, mirrors, and various objects of ornament.*

For the first precise description of these mines we are indebted to Edward B. Tylor,† who visited that interesting spot in 1856, while traveling through Mexico in company with Mr. Christy. Besides many facts relating to the archæology and ethnology of Mexico, this writer furnishes the best observations on Mexican obsidian. Of the mines, he says:

"Some of the trachytic porphyry which forms the substance of the hills had happened to have cooled, under suitable conditions, from the molten state into a sort of slag, or volcanic glass, which is the obsidian in question; and in places this vitreous lava from one layer having flowed over another which was already cool, became regularly stratified. The mines were mere wells, not very deep, with horizontal workings into the obsidian, where it was very good, and in the thick layers. Round about were heaps of fragments, hundreds of tons of them; and it is clear, from the shape of these, that some of the manufacturing was done on the spot. There had been great numbers of pits worked, and it was from these little mines—*minillas*, as they are called—that we first got an idea how important an element this obsidian was in the old Aztec civilization. In excursions made since, we traveled over whole districts in the plains, where fragments of these arrows and knives were to be found literally at every step, mixed with fragments of pottery, and here and there a little clay idol."

* Humboldt refers to it in his *Essai Politique sur le Royaume de la Nouvelle-Espagne*, vol. ii. (liv. iii.), p. 122.

† *Anahuac, or Mexico and the Mexicans, Ancient and Modern.* London, 1861.

This locality furnished a large part of the obsidian so widely distributed throughout the whole Southwest. In Mexico and Central America implements and fragments abound everywhere, indicating extensive traffic; and at points like Tenochtitlan (the modern City of Mexico) and San Juan Teotihuacan, the refuse-heaps are black with thousands of pieces.

An interesting account of these great obsidian mines in the State of Hidalgo has been given recently by Prof. W. H. Holmes, of the United States National Museum. They are among the most remarkable and important of the prehistoric mines found in various parts of North America.

"Prof. Holmes, Prof. G. K. Gilbert and Mr. W. W. Blake made the visit together. Leaving the railroad at Pachuca, the hacienda of the Guajalate estate is reached by a ride of 15 or 20 miles, and the mines themselves, several miles beyond, by a forest trail. They lie on the lower slopes of the Sierra de Las Navajas, or Mountain of the Knives. The slope is partly covered with long grass, partly with undergrowth, and partly with open pine woods; and as the actual mines are reached the surface becomes exceedingly irregular and difficult to traverse, owing to the alternation of heaps and ridges of obsidian fragments and the pits and excavations whence they came, half-concealed in the long grass and underbrush.

"Prof. Holmes compares these workings with those at the two great flint quarries of North America—at Hot Springs, Ark., and Flint Ridge, Ohio—and estimates them as perhaps about equally extensive. They must have been exploited for a long period, as hundreds of acres have been worked over, and the ridges and depressions are practically continuous for 1 or 2 miles in length, and in some places for half a mile in breadth. There is no regularity whatever in their disposition; some are isolated pits, others coalesce and form half-continuous trenches over acres of ground. All are very fresh in appearance, although four centuries have passed since they were abandoned; but obsidian is a material that does not weather or decompose, and the flakes and fragments are as sharp and clean as if perfectly fresh. The trenches rarely exceed 6 or 8 feet in depth, and the heaps and ridges are but little more in height; but some of the excavations are like wells or pits, 15 or 20 feet deep, with vertical or overhanging sides. Prof. Holmes surmises, from the quantity of *débris* piled in horseshoe-like mounds around them, that these may have led to oblique or horizontal tunnels of some length; but it was not practicable to explore them for lack of tools.

"The material taken out from the ground must have been carried to certain points at hand; there tested as to its quality; and, if this proved good, trimmed into the cores that were taken away and widely distributed as an article of Aztec trade. The points where this testing and trimming were done are marked by immense piles of pure obsidian flakes and rejects, unmixed with any earth, and all perfectly sharp and fresh. The principal one of these heaps Prof. Holmes estimates to contain 20,000 to 30,000 cubic feet. It forms a long slope, with a flat top about 20 by 40 feet in area, where, doubtless, the workmen sat. Vestiges of rude stone buildings were recognized, one near this pile, and others lower on the slope of the hill; but all were reduced to low, ruined walls.

"The actual occurrence of the obsidian itself was not seen. There was not visible outcrop, and the pits and trenches were so filled up below with fragments and *débris* that the material could not be observed *in situ*. It must occur almost immediately beneath the surface, in irregular beds or masses of considerable extent. Many of the fragments are of large size and quite homogeneous. The color is chiefly black, or nearly so, though some is found of a paler shade—greenish, with chatoyant reflections. Hammer stones of tough lava, worn and battered by use, were the only tools or implements found. These were of two types, the larger ones discoidal or cheese-shaped, similar to North American forms, and the smaller ones nearly globular. They must have been used for breaking larger and smaller masses of the obsidian, respectively, but cannot have been employed for any of the finer shaping or flaking.

"Prof. Holmes gave much attention to the 'cores' or nuclei so familiar in all Mexican archæology as the source of the flaked knives and blades. The *débris*-heaps are full of these in an interesting form—cores roughly blocked out and then rejected as not valuable or satisfactory, owing to lack of homogeneity or of good flaking quality. Judging from those rejected, the average size must have been 4 or 5 inches in length and 2 to 4 in diameter. Larger ones are known, but are rare. They are rudely cylindrical or polygonal, and bear a few facets, made to test their quality. The number of better ones carried away must have been enormous.

"These nuclei were evidently distributed all over the country as the raw product of the mines, and were then worked up into all the forms of knives, razors, and other flaked implements, as well as those modified by chipping and shaping, as arrow-heads, scrapers, etc. The flaking was not done at the quarry, as the delicate edges would be liable to injury in transportation. The further history of a 'core' is described and illustrated from abundant specimens by Prof. Holmes. The flaking was carried on upon any nucleus as implements were made from time to time, the size of the 'core' and the width of the flakes removed from it decreasing as the process went on. Whether the force was applied to the end of the nucleus by percussion or by pressure is not certain. Finally the core became so reduced that nothing more could be flaked from it, and these exhausted nuclei are common objects around old inhabited sites."

Obsidian objects are occasionally found in the United States as far east as Ohio and Tennessee. But it is useless to speculate as to their source, inasmuch as the distance from Central Ohio is about the same,—some 1700 miles,—to either the Yellowstone Park, the regions of the Gila, or ancient Mexican mines. Moreover, the number of such objects found east of the Mississippi is so small that little significance attaches to them.

The obsidian-work in ancient Mexico appears under three distinct types,—flaked objects, chipped objects, and polished objects. The knives, as already noted, were for the most part "flaked," by either pressure or percussion, from a mass, which finally became a "core." They are usually long, thin slips, with

two parallel sides, exceedingly sharp-edged, and blunt ends, the sides being generally somewhat curved on their surfaces. These were fastened into handles, probably of wood, by asphalt or some black cementing substance, traces of which may often be seen at one end of the razor-like blade.

For arrows or spear-heads, the flaked piece was subjected to a chipping process, to produce a point and to give symmetry of form. Sometimes they were very large, and must have required a great amount of careful work. Two such blades or lance-heads 18 inches long, both Mexican, almost identical in form, and marvels of fine chipping, are preserved, one in the W. W. Blake collection, U. S. National Museum, Washington, D. C., and the other in the Trocadero collection, at Paris. One or two similar examples, though not quite as large, were shown in the Mexican section in the Ethnology Building at the Buffalo Pan-American Exposition of 1901.

The polished articles are objects of ornament,—mirrors, labrets and the like. Examples of these are to be seen in the National Museum at the City of Mexico; the U. S. National Museum; the Trocadero collection at Paris; the British Museum; and in all leading archæological collections.

A number of the finest known mirrors and engraved plaques of obsidian are in the Trocadero museum. A square one from Texcoco, measuring 9.5 by 8.5 by 1.2 in. (24 by 21.5 by 3 centimeters), and a round one, convex on one side, from Oaxaca, 6.5 in. (16 centimeters) in diameter, are wonderful pieces of primitive stone-work. The one possessing the greatest archæological interest is the square plaque described by the director, Dr. E. Hamy, on which is the inscription, "*Ypanquetzalitzli* 4 *acatl*" (Dec. 9, 1483, the date of the laying of the first stone of the Great Temple of Mexico). The polished carved figures are exceedingly interesting.

No modern lapidary can do finer work than is shown in some of these old Aztec articles of obsidian. In the City of Mexico, articles are now sometimes offered for sale as antiques which are unquestionably of modern manufacture. These are, in general, crudely carved; and the polish is inferior to that of the ancient pieces. Among such imitations, the writer has observed dozens of masks of black obsidian with gray sheen, 8 in. high, and two figures of small animals, besides other minor articles.

A richly-mottled, red-and-black, brown-and-black, or yellow-and-black variety of obsidian, called marekanite, or "mountain mahogany," is found in the State of Jalisco, often in sufficiently large masses to be useful as a decorative stone, since it admits of high polish. Associated with it in considerable quantity are pearl-stone or sphærulite, which shows reddish-brown spherules in a gray matrix, and pitchstone, a related mineral, which has, however, the luster rather of pitch than of glass. Mineralogically, obsidian is, for the most part, orthoclase, or potash-felspar, while pitch-stone is nearer to oligoclase and albite, containing soda and lime in place of potash.

To sum up the results of this art, we have as the first step of the lapidary process, "flaking," performed upon the wonderful obsidian, producing the flakes used as knives or razors. As the result of subsequent chipping, we have spears and knives, 14 inches in length, which are marvels of careful and patient work. Finally, as polished ornaments, we have labrets, or lip-ornaments; rings, for the nose and ears; ornaments as well as mirrors that measure 2 ft.; crosses, and other carved objects. The labrets are frequently as thin as paper, and possess a faultless polish. There is in the Mexican National Museum a large figure of a monkey, some 8 in. across, worked out and down to the thinness of paper.

Pyrite (*Iron Pyrites ; Iron Bisulphide*).—This mineral also was, to some extent, wrought by the ancient Mexicans into mirrors and other ornamental objects. The mirrors were generally convex on one side and polished flat on the other; and the polish is frequently still retained and very brilliant when cleaned. The convex side was often curiously carved and decorated. There are numbers of these pyrite mirrors in the Trocadero (Paris); the U. S. National (Washington); the Field Columbian (Chicago), and other museums, and our ex-president, Mr. John Birkinbine, possesses a very fine one. Among other objects, two are notable: (1) in the U. S. National Museum (Blake collection), a human head, 2 in. high, into which have been inserted eyes of white chalcedony; (2) in the Christy collection, London, two human skulls, encrusted with turquoise, in which the eyes are represented by polished balls of pyrite.

This iron bisulphide, though a very common mineral, is rarely found in masses pure and compact enough to be cut into

such objects as those above described. There must have been in Mexico a locality where it so occurred, and perhaps might still be obtained; but the place appears to have been entirely lost. I need hardly say that its rediscovery would be highly interesting to both archæologists and mineralogists.

Tecali, or Mexican Onyx.—This beautiful stone has been for some years past one of the most important mineral products of the Republic. It was carved by the Aztecs into a variety of objects, now to be seen in collections. The name *tecali* is that of its principal locality, and is itself a modification of the Mexican *Teocali*, a temple, literally "house of God," like the Hebrew Beth-el. In 1876, the crude, rough stone commanded $50 per cub. ft. At present the same quantity is sold for, say, one-tenth of that price, or even less. When first introduced into modern art, it was said to come from the vicinity of Puebla; but it is known to occur at several points—Tecali, Tehuacan, Etla, etc.,—in the States of Puebla and Oaxaca, and also in Durango and Coahuila, where it has been more recently found. The magnificent specimens which surprised the world, when first shown at the U. S. Centennial in 1876, were even finer than those shown at the Paris Exposition of 1900. This Mexican onyx has been an important source of profit to Puebla and Oaxaca, and may become such to Durango and Coahuila, or some of the many other regions in Mexico which contain numerous caves in limestone.

A few years ago, very fine material of this kind was discovered and worked at New Pedrara, in Lower California. The pink variety, here found, which is quite rare, was much admired at the Chicago Columbian Exposition of 1893. But the locality appears not to be worked.

Mineralogically, this Mexican onyx is classed as an aragonite. Dr. Mariano Barcena, of the Mexican Commission to the Philadelphia Centennial of 1876, has published an account of its occurrence and chemical character. It is a carbonate of lime, containing small quantities of the oxides of iron and manganese, to which are due the variegated colors for which the rock is so much admired. The specific gravity, 2.9, shows that it is aragonite. As already remarked, it was extensively used by the ancient Mexicans, specimens of whose handiwork are preserved in our museums in masks, idols, and a variety of

other objects. The softness of the material (it can be readily carved with a knife) has tempted some of the modern Mexicans to imitate these ancient objects, in order to meet the demand of tourists; and within the past ten years fully one hundred times as much Mexican onyx has been thus shaped and wrought as was ever used in ancient Mexico. The modern artists often present grotesque, fearful forms, which sell much better than the real antiques or simple copies of them.

This material is entirely stalagmitic in its formation, and carries yellow-brown and red oxides of iron, deposited between layers of the aragonite. It is generally cut across the layers, and thus acquires a beautiful veined appearance. When it is cut, however, parallel with the layers of deposition, a botryoidal structure is well shown, the mineral being so translucent that the colored markings resemble colored clouds. It is one of the most beautiful ornamental stones of any age, and has been used extensively for ornamental purposes in Europe, as well as in the United States, where it was first introduced about 1876. The natives in the vicinity of Puebla sell a great deal of it in the form of trays, crucifixes, reliquaries, inkstands, penholders, paper-folders, paper-weights, single fruits or bunches of fruit, fish, or other natural objects, which are skillfully carved, not only as to shape, but often with remarkably happy utilization of the colors in the stone. So great is the variety of tints in which the material is found, that there is scarcely a limit to its possibilities for such purposes. Bernardino de Sahagun refers to *iztac chalchihuitl*, white or fine green, and transparent, obtained from quarries in the vicinity of Tecalco, which Dr. Daniel G. Brinton belives to be the modern Tecalco; and the description and locality answer so well to those of our "Mexican onyx," that there can be little doubt that this stone is Sahagun's *iztac chalchihuitl.*

In 1888, Mr. William Cooper, of Esperanza, discovered in the volcano of Zempoatepetl, in southern Mexico, a deposit of a beautiful mineral, to which he gave the trade-name of "mosaic agate," but which is really the same as Mexican onyx, or aragonite—with this difference, however, that while the Mexican onyx is always veined or stratified, the new material is a brecciated or "ruin"-aragonite. The original formation has evidently been entirely broken up, the fragments having been sub-

sequently cemented together, and the crevices all filled with a new deposition of aragonite. In other words, a deposit of Mexican onyx was fractured by some disturbance (probably volcanic), and later deposition of the same material has cemented it into its present form. Like the true *tecali*, it is susceptible of a high polish, the difference between the two being that, in the "mosaic agate," the straight bands of color characterizing the "onyx" aragonite have been broken up and disseminated in fragments throughout the mass, giving an even more pleasing and brilliant appearance. It can easily be cut into thin slabs, makes beautiful ornamental tops for tables and bureaus, and has also been cut into solid columns, and used for the pedestals of busts and statues. For some years past, however, little has been heard of this promising material.

Geologically, the Mexican onyx-deposits are regarded as chiefly of Quaternary age, though those near Tehuacan, at San Antonio de las Salinas, in Puebla, are referred, with probability, to a late date in the Pliocene Tertiary.

Amber.—For 15 or 20 years past, specimens of a remarkable amber have occasionally been brought by travelers from some locality in southern Mexico. The only information gained concerning it is that it is brought to the coast by natives, who say that it occurs in the interior so plentifully as to be used for making fires. It is rich golden-yellow in color, and, viewed in different positions, exhibits a remarkable fluorescence, similar to that of uranine, which it also resembles in color. A specimen, lately belonging to Mr. Martius T. Lynde, but now in the Tiffany collection, Field Columbian Museum, measures 4 by 3 by 2 in., is perfectly transparent, and even more beautiful than the famous so-callel "opalescent" or green amber found in the Sicilian province of Catania. It would be extremely valuable in the arts, if it could be furnished in adequate and regular supply.

Amber was used as an incense by the Aztecs. Fragments have been found on the altars of ancient temples, and also in the Catholic churches in early Mexico. A small flat disk 1.5 in. in diameter, and engraved like the center of the Mexican "Calendar-stone," is in the Field Columbian Museum, Chicago. Like the amber found in the Roman excavations, in Europe, it has a gray or, opaque outer coating, on a rich brown interior.

Résumé.

The following propositions comprise the conclusions which may be drawn from the foregoing pages, together with statements concerning gems, etc., not discussed, and, in the writer's judgment, not needing to be discussed in this paper:

1. No authentic record is known of the discovery of the diamond in any Mexican State.

2. Sapphire has been found in one instance, as specified on a preceding page.

3. Small emerald specimens, attributed to a locality in Guerrero, are shown at the School of Mines in the City of Mexico.

4. Topaz, in a beautifully crystalline red variety (not yellow topaz, like that of Brazil) has been found at San Luis Potosi and in Durango.

5. Tourmaline has never been found in Mexico.

6. Turquoise is not known to-day as occurring in Mexico; yet, in view of the considerable use of this stone by the Mexicans of pre-Columbian times, it must be considered as possible, at least, that localities containing it were once known, and may be hereafter re-discovered. Yet it is not impossible that turquoise was obtained by the ancient Mexicans through barter with the peoples to the north of their country.

7. The precious or "noble" opal is found in considerable abundance, but not often of the best quality and highest value as a gem, though, so far as beauty is concerned, the Mexican "fire-opal," with its magnificent profusion and variety of color, rivaling the delicate splendor of the humming-bird, has never been surpassed by the opals from other parts of the world. The disadvantages of the Mexican opals have been sufficiently discussed above.

8. Concerning other minerals already enumerated as used by the ancient Mexicans, such as the other quartz gems, pyrite and obsidian, it may be fairly said that, however interesting to archæologists, they present, at this time, no prospect of value as assets of national wealth or bases of profitable industry.

9. Jadeite, which has been discussed at considerable length in this paper, offers to mineralogists and archæologists a fascinating problem, the solution of which might prove valuable to mining engineers, jewelers, and patriotic political economists also. We are confronted by the startling fact that the museums

of the civilized world contain thousands of Mexican objects, wrought with great skill and artistic finish from a material of great durability and beauty, especially when, as is sometimes the case, it possesses a deep green tint scarcely equaled by that of the emerald itself.

What were the original sources of this beautiful and valuable material? Do any considerable deposits of it exist in Mexico? That is not impossible. We may find such a deposit any day. But we must confess that the manufactured objects known to us indicate no knowledge of the mineral in place to have been possessed by the ancient Mexicans. They seem to have obtained it exclusively from pebbles or boulders in the beds of streams, and never to have followed such stream-beds upwards to a solid original deposit. On the other hand, that does not prove that such a search would not lead modern prospectors to jadeite deposits, even equaling those of the famous mines in Burma.

The evidence now at hand from China (where jade has long been a highly-prized art-material) or Burma, where it has been mined with great profit, does not help us much in studying the Mexican problem. One thing seems, however, to have special significance, namely, that neither jadeite nor articles wrought from it have been found so far north as Queretaro, in Mexico, and, so far as now known, have never been found in the neighboring United States. These seem to prove that it was not imported into Mexico; that it was never produced there in sufficient quantities to be exported; that the limited product of it was kept at home for religious or other reasons; and, finally, that the rich deposits of it *in situ*, if such exist in Mexico (as they certainly do in Burma), are probably not far from the districts where it was gathered in pebbles and boulders, to be paid as tribute to conquerors, and to be wrought into objects of religion and art.

From both the scientific and the commercial standpoint, the problem thus presented is not unworthy of attention from members of the American Institute of Mining Engineers.

The Value of Ores in Mexico.

BY N. H. EMMONS, 2ND, PARRAL, CHIHUAHUA, MEX.

(Mexican Meeting, November, 1901.)

In the United States the value of gold- and silver-ores is everywhere reckoned in ounces troy of the metal per "short ton" (2000 lbs. avoird.) of the ore. In the case of silver, which fluctuates in market value, the New York quotation on a given day must be known, in order to determine the gross value of an ore at that date.

In Mexico the assay is reported in kilogrammes of silver or grammes of gold per metric ton. As everyone is aware, this is practically a percentage system, 1 kg. of silver per metric ton (1000 kg.) being 0.1 per cent.; and 1 gramme of gold per metric ton, 0.0001 per cent. The notation is simple and convenient for both assayer and miner.*

The Mexican government purchases at an unvarying price for silver, payable in silver, and at a fixed price for gold, payable in gold if the seller insists, but preferably in silver at about the rate of exchange between U. S. gold coin and Mexican silver coin. The value of silver is $40.915 per kilogramme in Mexican silver dollars. That of gold is $675.416 per kilogramme in gold coin. The mints do not, as a rule, issue gold dollars, as the government keeps them to pay the interest on the national debt. Almost all bullion containing a considerable percentage of gold is shipped to foreign countries (principally the United States) to be refined.

The Mexican mint receives for refining and coining no bullion which is not at least .950 fine in gold and silver, separately or

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* Note by the Secretary.—The complicated calculation required to convert into percentage (so as to correspond with the form in which all other ingredients of an ore, as determined by analysis, are always reported) the U. S. expression of "oz. per ton," is as follows:

The only unit common to the avoirdupois and troy system is the grain. The avoirdupois pound contains 7000 grains; hence a "short" ton contains 14,000,000 grains. The troy ounce is 480 grains; hence a "short" ton contains 14,000,000 $\div$ 480 = 29,166⅔ troy ounces. One troy ounce per "short" ton would be, therefore, $\frac{1}{29{,}166\frac{2}{3}} = \frac{3}{87{,}500} = 0.00342857 +$ per cent.—R. W. R.

combined. For the fine silver, it pays $40.915 Mex. per kilo, less 2 per cent. coinage-charge and 3 per cent. stamp-tax. For assaying each bar, not more than 35 kg. in weight, $2.50 Mex. is charged, and for separating gold from silver, $0.75 per kg. of bullion. Gold (if over 3-1000ths is present) is paid for at $675.416 gold per kg.; but payment is made in silver dollars at about 10 points below the current quotation of exchange. Finally, the State tax about to be mentioned is collected upon bullion, unless it has been previously paid on the ore.

Government charges practically unknown in the United States are the taxes on ores of silver or gold, paid both to the Federal and to the State governments throughout the Republic of Mexico. These taxes (being laid upon gross product, without reference to profit) are likely to be so severe that in many parts of the Republic it has been the custom not to insist upon the payment of the full State tax. The Federal tax, however, known as the mintage-tax, is collected upon all the gold and silver produced in the country—either at the mints upon the bullion presented for coinage, or at the points of export upon ores or bullion shipped to other countries.

The State "extraction-tax" is levied on ores mined, and supposed to be collected before the ores leave the mine-yard or "patio." This has been found, for many evident reasons, impracticable; and it has come to be the custom to collect the tax as the ores leave the mining camp, or, if they are treated in the camp, then as the product is shipped away. The government may accept the sampling and assays of the owners; or an official may be sent to superintend the sampling, and take a special sample for government assay. The manifest of the shipper states the number of metric tons shipped, and of kilogrammes of silver and gold per ton. The collector calculates the silver-value of the shipment at $40.915 per kg. of silver, and collects 2 per cent. of that value for the State, and also, according to the Federal statute, 30 per cent. of the State tax, or 0.6 per cent. of the value, as the Federal tax. The total (2.6 per cent. on $40.915) is a direct tax on the silver in the ore of $1.0638 per kilogramme, or (1 kg. being 32.15 oz. troy) about 3.3 cents per oz.

If the ore is smelted in Mexico, the smelter pays the tax; if it is exported, it must be accompanied with a consular invoice, and sampled and assayed at the border by the Mexican govern-

ment. In this case the mintage-tax (that is, the charge which would have been made if the bullion had been sent to the Mexican mint) is also collected. For bullion, matte or other metallurgical product, this tax of 5 per cent. is collected upon the full assay value of the metal contained. For ores, it is collected upon 90 per cent. (and is therefore 4.5 per cent.) of the assay-value.

Finally, if ore is sold to any purchaser in Mexico, there must be a bill of sale, or "*factura*," on which revenue-stamps to the amount of 3 cents for every $5 or fraction thereof are affixed and cancelled by the seller. This stamp-tax is not peculiar to sales of ore. It is required for every sale of merchandize amounting in value to $20 or more. The value here contemplated, however, is not the gross value, calculated as above described, but the net value, or amount paid by the purchaser.

It will be seen that the taxes on ores of gold or silver mined in Mexico comprise 2.6 per cent. of gross value as State and Federal extraction-tax, plus 4.5 per cent. as mintage-tax, or, in all, 7.1 per cent. on the gross assay-value, to which must be added the stamp-tax on the *factura* of 0.6 per cent. on the net value.

In order to show how the value of a given ore to the miner is determined, it will be convenient to assume an example, bearing in mind that some of the conditions stated would vary with the locality. In most districts, the regular gold-price paid by the smelters for silver in ores is 90.5 per cent. of the New York quotations; for gold, 95 per cent. of the assay, at $19.50 per oz.; and for lead (if the ore is a rich lead-ore), 1 cent per lb. on 90 per cent. of the contents as per assay; allowances for freight and treatment being made according to local conditions —the latter, according to a regular scale for "neutral" ores, with suitable modifications for departures from that quality. We will assume $9 U. S. money per "short" ton for freight and treatment, and take as a basis the New York quotations of Sept. 20, 1901, which were 58.25 cents per oz. for silver, and 4 cents per lb. for lead. Bankers' exchange in the City of Mexico on the same date was at 1.165 per cent. premium.

We assume also a neutral ore containing per metric ton, 1000 grammes of silver and 3.43 grammes of gold (*i.e.*, 29.167 oz. silver and 0.1 oz. gold per ton of 2000 lbs.) and 20 per cent. of lead. This ore would pay the miner as follows:

The silver, at 58.25 cents per oz., would be worth $18.728

U. S. currency per kilo, and would be paid for, as above stated, at 90.5 per cent. of this value, making upon the ore assumed \$16.96 for silver. Gold at \$19.50 per oz. would be worth \$0.626 per gramme; and 95 per cent. of 3.43 grammes at this price would bring \$2.04. Of the 20 per cent. of lead (200 kg. per ton) 90 per cent., or 180 kg., would bring 1 cent per pound (2.204 cents per kg.), or \$3.97. The total for silver, gold and lead would thus be \$16.96 + \$2.04 + \$3.97 = \$22.97 U. S. currency per metric ton, apart from the extraction-tax and stamps on "factura," freight and treatment. (The purchaser, paying for only 90.5 per cent. of the silver and 95 per cent. of the gold, assumes the mintage-tax.)

Deducting the assumed treatment-charge of \$9 per short ton, which is \$9.92 per metric ton, we have as the net returns to the seller \$22.97 — \$9.92 = \$13.05 U. S. currency per metric ton. But from this he must still pay the extraction-tax of 2.6 per cent. on the nominal value of \$40.915 per kg. of silver and \$675.416 per kg. of gold (reduced to silver at about 2.10 exchange), or, upon the ore here assumed to contain 1 kg. silver and 3.43 grammes gold per ton, \$1.18 in Mexican money, and also the stamp-tax of 3 cents for each \$5 Mexican money. Reducing the above return of \$13.05 to Mexican money we have (\$13.05 × 2.165) \$28.25, which would require 18 cents stamp-tax. Consequently the ultimate net return to the seller would be, in Mexican money, \$28.25 — (\$1.18+\$0.18) = \$26.89.

Recalculating on the American basis of ounces per short ton, we would have as the value per short ton of the ore under consideration:

Silver: 90.5 per cent. of 29.167 oz. at 58.25 cts.,	\$15.38
Gold: 95 per cent. of 0.1 oz. at \$19.50,	1.80
Lead: 90 per cent. of 400 lbs. at \$0.01,	3.60
Total in U. S. money,	\$20.78
Less treatment charge per ton,	9.00
Net value in U. S. money per short ton,	\$11.78
Or, in Mexican money, at (2.165),	25.50

From this we have to deduct the extraction-tax, which is, as above stated, \$1.18 per metric ton (2.204 lbs. avoird.), and would therefore be per "short" ton, \$1.18 × 2000 ÷ 2204 = \$1.07, Mexican money. And, finally, the stamp-tax on the *factura* would be, as before, 18 cents, making total deductions

of $1.25. Subtracting this amount from $25.50, we have a final net return per short ton of $24.25 Mexican or $11.20 U. S. currency. It will be understood, of course, that this calculation is simply a re-statement of the one previously stated, and is introduced simply to facilitate comparison for those who are not accustomed to reckon by the Mexican method.

Two comparative statements will be specially interesting to American miners and sellers of ore, as showing respectively:

1. What would be the net return in the United States for ore sold under the same conditions, *i.e.*, with freight and treatment at $9 per ton, and lead quoted at 4 cents per lb. in New York; and

2. How the value of such ore in Mexican money will be affected by an extremely high or low market price of silver.

1. Ore of the character assumed above, if mined in the United States and sold under the same conditions as to freight and treatment charge and price of lead, would return to the miner 95 per cent. of the silver-value, or $16.14 instead of $15.38; 100 per cent. of the gold-value at $19.50 per oz., or $1.95 instead of $1.80; and 90 per cent. of the lead-value at full New York quotations of 4 cents per lb., or $14.40 instead of $3.60, making a total of $32.49, instead of $20.78, per "short" ton. Deducting $9 for freight and treatment, we have $23.49 U. S. ($50.86 Mex.) as against $11.20 to the Mexican miner of the same ore, situated at an equal distance from the smelter.

2. The effect of fluctuation in the price of silver upon the value of Mexican ores may be illustrated by assuming that silver is quoted in New York at 40 cents per oz. instead of 58.25 cents, as in the above examples. In that case, exchange will be forced up to $3.18. We would then have, per ton of 2000 lbs., 95 per cent. of 29.167 oz., at 40 cents, or $10.56 instead of $15.38 for the silver, and the other items would remain unaltered, so that the total would be $15.96, or, after deducting $9 as before, $6.96 U. S., which, however, by reason of the higher rate of exchange would be $22.13 Mexican, as against $25.50 Mexican with silver at 58¼ cents. It will be seen that the increased value in Mexican currency of the gold and lead, due to the lower price of silver and the consequent rise in exchange, greatly diminishes the loss on the silver in the ore.

To elucidate still further the bearings of this curiously-balanced and complicated set of constant and variable factors upon

the Mexican mining industry, let us take as an example a reduction-works, located at the mine, and so situated with regard to ores, fluxes, etc., as to be able to produce bullion high enough in silver to be sold directly to the Mexican mint. In other words, the standard value of $40.915 per kg. will be received for the silver, and in lieu of $9.92 U. S., charged for freight and treatment, the charge for treatment will be $15 Mexican per metric ton. Omitting, for simplicity, gold and lead, and considering the ore to carry silver only, the miner will receive per metric ton, on ore containing 1000 grammes of silver, $40.915 -$15 = $25.91 Mexican, less the taxes and duties above set forth. This return is independent of the price of silver. If silver drops to 40 cents, as above supposed, he will still receive $25.91, Mexican, less the same taxes and duties as before—only the exchange-value of this sum will be smaller, by reason of the higher rate caused by the fall in silver. But this smaller exchange-value does not affect his expenses for labor and power, because wages, fuel and domestic supplies are paid for in Mexican money, without regard to temporary fluctuations in the market-price of silver. It is only in the purchase of imported supplies for mining and milling, or machinery, etc., needed for repairs or new constructions, that the difference is felt. Of course, any dividends that might be paid, though they would be no smaller in Mexican money, would be reduced in value to foreign owners by the higher rate of exchange.

Lead has very little value for the Mexican miner, since the price paid for it by smelters is practically nothing, compared to what is paid in the United States.

Copper- and gold-ores pay more profit to the Mexican miner (whether calculated in U. S. or in Mexican money) the lower the price of silver and the higher the rate of exchange.

Profits (estimated in Mexican money) from silver-ores, if they can be treated locally, at expense chiefly payable in Mexican money, are affected only by the amount of imported supplies required for their treatment. If they go to smelters which make their charges in U. S. money, the returns will depend on the price of silver and the rate of exchange.

As a general conclusion, it may be said that, by reason of the peculiar conditions explained and discussed above, the mines of Mexico are less dependent upon the market-price of silver than those of the United States.

The Sierra Mojada, Coahuila, Mexico, and Its Ore-Deposits.

BY JAMES W. MALCOLMSON, CHIHUAHUA, MEX.

(Mexican Meeting, November, 1901.)

INTRODUCTION.

THIS paper treats of the history and development of the Sierra Mojada mines in the north of Mexico, the character and extent of the ore-deposits, and the methods of mining the ore.

The growth of the smelting industry in Mexico in recent years is, to a large degree, due directly to the output of the lead-bearing ores from the Sierra Mojada mines, and at the present time (1901) new smelters are being built, looking to this district for their supply of lead-ores.

These mines are located in the southern part of the State of Coahuila, in the Republic of Mexico, in latitude 27° 24′ N. and longitude 103° 43′ W. of Greenwich.

The last account of the Sierra Mojada published in our *Transactions* was contributed by Mr. Richard E. Chism, in October, 1886.* Since that time some 3,000,000 tons of ore have been extracted from the mines, and much additional information has been developed regarding the mineral deposits.

Since 1886, the Mexican Northern railroad, 78 miles in length, has been built from Escalon, connecting the camp with the Mexican Central railway, a trunk-line from El Paso, Texas, to Mexico City.

The distances by rail from Sierra Mojada to the principal smelting-centers are as follows: To Torreon, Coahuila, Mex., 179 miles; to Monterey, Nuevo Leon, Mex., 422 miles; to El Paso, Tex., U. S., 494 miles; to Aguas Calientes, A. C., Mex., 522 miles; to San Luis Potosi, S. L. P., Mex., 644 miles; to Pueblo, Colorado, U. S., 1158 miles; to Argentine, Kans., U. S.,

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* *Trans.*, xv., 542.

1661 miles. The larger proportion of the ore mined hitherto has been shipped to El Paso, Tex., and to Monterey, Mex.

I. History.

In June, 1878, a certain Nestor Arriola or Arriolana obtained permission from the government to form a band of men to go to this part of the desert and watch for a party whom he suspected to be coming from San Antonio, Tex., with a load of contraband goods. He thought the smugglers would pass near the mountains where the mines are to-day; but they took another road, thus causing him to spend several idle days. During this time he found some lead-bearing ore, of which he had assays made at his home in Mapimi; and, finding that it contained silver, he returned with some prospectors, located the Blanca mine, and also sunk a winze on what is now the Jesus Maria mine. The camp soon obtained an immense amount of notoriety, as the following extract from Mr. Chism's paper shows:

> "Some years ago, when I was seeking an illusive fortune in the primeval forests of Brazil, there penetrated even to my headquarters in that far-off land the story of a new-found mining district, where mountain peaks were ribbed with silver and valleys teemed with virgin gold. . . . The . . . stories caused hundreds of men to seek their fortune in Sierra Mojada, and to return heaping curses, loud and deep, upon the vivid imaginations that had evolved the glittering fiction."

One expedition went from Pachuca in 1879, under the direction of the Real del Monte Mining Company, which sent a fully-equipped party to the camp—a distance of more than 600 miles overland—by stage and wagon.

The mines are in the midst of an extensive desert, and at the time of their discovery the nearest railroad point was San Antonio, Tex.

In the early period of its development, the camp was claimed by the adjoining States of Chihuahua, Coahuila and Durango. Until the rival claims were settled, the district was governed as a Territory by the national authorities. It was finally declared to be a part of the State of Coahuila; and, at the present time, 30 per cent. of the entire revenue of that State is derived from taxation of the Sierra Mojada mines and their products.

The first ore-bodies discovered were basic lead carbonates in limestone, outcropping at the surface, and lying nearly horizontal, with a slight dip to the south. For several years these were the only deposits known to exist; but eight years ago very large ore-bodies of siliceous copper-ore, high in silver, were discovered. Latterly the limestone itself in the vicinity of the copper- and lead-ore deposits has been worked with success, by reason of the silver chloride disseminated through it.

The mines were originally worked by their Mexican owners in a somewhat primitive style; but in 1887 a great impetus was given to their development through the acquisition of the control of the two principal mines, the San Salvador and the San José, by the Consolidated Kansas City Smelting and Refining Co. Since then, American methods and American capital have been employed with great success in opening up the mining properties; and to-day nearly the entire output is produced under American control and supervision.

In the early days the ore was freighted by teams 75 miles to Escalon, and shipped over the Mexican Central railroad to El Paso, Tex., or to Argentine, Kans. No duties were collected by either the Mexican or the United States government. In 1889 a local duty of 2.6 per cent. of the value of silver- and lead-contents was imposed; and, since 1896, an additional duty of 4.5 per cent. on the silver-contents has been collected at the frontier by the Mexican Federal government; and by a decision of the U. S. customs authorities, ratified by subsequent legislation, a duty of 1.5 cents per lb. of the lead has been collected on its admission into the States.

To-day, on the average grade of ore (assaying 10 oz. of silver per ton and 15 per cent. of lead) produced in the Sierra Mojada, and shipped to the U. S., 7 per cent. of the value of the silver-contents is collected by the Mexican, and 37 per cent. of the value of the lead-contents by the U. S. government, or, in all, between 50 and 60 per cent. of the amount paid by the smelter to the miner for the ore on the mine-dump.

Much of the lead-ore shipped at the present time to the U. S. is smelted in bond, in the same manner as the Canadian lead-ores, and subsequently sold outside of the country.

The decision of the U. S. customs authorities—known as the Windom decision—was the result of strong representa-

tions of the Colorado smelters, who believed that Mexican lead, mined by so-called "pauper-labor," was ruining their business, through the competition of the Missouri river smelters, to which points the Sierra Mojada ore was shipped. The apparent results after the imposition of the duties were, that the Colorado miners were charged $1.00 more per ton for the treatment of siliceous ores, on account of the diminution of the lead-supply; a powerful and successful smelting industry, employing thousands of men, has been developed in Mexico by the investment of millions of dollars, largely of American capital; and another result has been that Missouri lead-ores, low in silver, have been diverted from their natural path East over a long westerly detour, first to Colorado, and finally back to the East again, as bullion.

II. Production.

The early production of the Sierra Mojada was small; but in April, 1886, Mr. Chism mentions that the weekly ore-product from the entire district was about 1000 tons, which would be, roughly, one-quarter of the present output.

Since the building of the Mexican Northern railroad in 1890, the average production has been approximately 200,000 tons annually. The production during 1900, from official returns, was 187,110 metric tons (2204 lbs. avoirdupois), as follows:

Mine.	Metric Tons.	Mine.	Metric Tons.
Veta Rica,	41,018	Jesus Maria,	3,980
San José,	30,285	La Sultana,	3,039
San Salvador,	28,783	Parena,	2,475
Volcan Dolores,	15,552	Buena Ventura,	2,040
Tiro Juarez,	14,331	Exploradora,	1,017
Encantada,	13,470	Tiro 10,	646
Tiro 11,	10,595	San Francisco,	530
Esmeralda,	7,931	Galan Zona,	190
Providencia,	6,032	La Aurora,	5
Fortuna,	5,191		

On account of the inaccessibility of the camp, no ore was considered worth mining, in the early period of operations, which did not assay 20 oz. silver per ton and 25 per cent. of lead, with a large excess of iron over silica. Mr. Chism, in his paper, mentions this as the minimum grade in 1886;* and Mr. Judson, in the subsequent discussion,† calls attention to the

* *Trans.*, xv., 552. † *Ibid.*, p. 588.

fact that lead, before that time, was valueless in the Sierra Mojada, to such an extent that the local smelters endeavored to produce a slag high in lead, thereby securing greater fusibility. Slags then made would contain as much as 30 per cent. of lead.

In 1892–6 a large tonnage of copper-ore was mined, assaying from 30 to 120 oz. of silver per ton, the whole production averaging between 60 and 70 oz. of silver per ton, with 4 to 5 per cent. of copper.

At the present time, practically the same ore-bodies are being worked which were discovered in the early period of development; but the improved conditions permit the profitable mining of a very much lower grade of ore than formerly. The following table shows approximately the tonnage, assay and analysis of the various ores mined in the camp during 1900:

	Metric Tons.	Ag. oz. per Ton.	Pb. Per cent.	SiO_2. Per cent.	FeO. Per cent.	CaO. Per cent.	$BaSO_4$ Per cent.
Basic lead-ore, . .	80,000	9.0	15.0	16.0	36.0	5.0	...
Siliceous lead-ore, .	23,000	10.0	14.0	34.0	22.0	2.0	...
Irony lead-ore, . .	7,500	3.0	15.0	3.0	58.0	2.0	...
Siliceous ore, . .	2,500	19.0	0.0	73.0	10.0	1.0	...
Irony ore, . .	1,000	1.0	1.0	3.0	77.0	1.0	...
Lime ore, . . .	25,000	8.0	0.0	7.0	3.0	33.0	...
Siliceous lime, . .	52,000	18.0	0.0	20.0	3.0	21.0	10.0

In all the mines now open there are very large bodies of mineral of the classes mentioned above, but lower in grade. In time, with lower freight- and treatment-rates, these will undoubtedly prove to be a source of profit.

III. Geology.

1. *General Description.*

The mountains forming the Sierra Mojada are entirely of limestone, of the Carboniferous series, which in this part of Mexico attains an enormous thickness. Their most prominent feature is an almost vertical cliff overlooking a small plain, three-quarters of a mile in breadth and 6 or 7 miles long, to the north. This cliff rises to a height of over 3000 ft. above the level of the plain, making an impressive and majestic view, shown in Figs. 2, 3 and 4. Fig. 4 gives an idea of the im-

mense scale of this cliff formation, the mines being hardly noticeable in the foothills.

In Mr. Chism's ideal section of the camp,* reproduced in Fig. 1, the general character of the folding movement of this great limestone formation is well represented, but it can hardly be considered as a simple bending, because in places on the Sierra Mojada precipice the limestone strata can be seen where they have been folded upwards to a vertical position at right angles to the normal dip. (See Fig. 5.) In addition, therefore, to the flexure observed and mapped by Mr. Chism, it is evident that faulting and dislocation of the strata have also taken place to some extent.

2. *The Alluvium.*

The alluvium described by Mr. Chism in his paper (see Fig. 1) has also, on further investigation, proved to be an interesting feature of the district. Instead of being a recent product of erosion, as Mr. Chism believed, it is covered, in places, with patches of Cretaceous lime, towards the east of the camp on the Trinidad and Parena claims (see Fig. 15) and towards the west on the Blanca claim. The Cretaceous lime, which exists in a capping forming the summit of the Blanca hill, is 100 ft. thick, and is well shown in the photograph of La Blanca hill in the left of Fig. 2.

This Cretaceous limestone, overlying the alluvium, is a proof that, after flexure and erosion of the great underlying limestone formation, there was a second submergence of the district below water-level. Apparently the Cretaceous lime is not in any way related to the ore-deposits; but it is of interest as showing the geological character of the changes which have taken place during the process of ore-deposition.

3. *The Breccia.*

Below the alluvium described by Mr. Chism (Fig. 1), and between it and the underlying limestone, there has been found another formation, namely, a porphyritic breccia, entirely different, both in appearance and in composition, from the conglomerate or alluvium above. The alluvium is composed of

* *Trans.*, xv., 548.

rounded boulders and pebbles of limestone cemented by calcareous material, and is a product of erosion of the surrounding mountains. The breccia below is made up of angular fragments of felsitic and granite rocks, cemented by a siliceous matrix.

The conglomerate is porous; but the breccia is impermeable. Advantage is taken of this fact to sink shafts through the conglomerate to the breccia, in order to obtain a water-supply, which is fairly abundant. The surface of the breccia, below the alluvium, is apparently in the shape of a trough or gulch, running from west to east; a shaft sunk on the Emma claim (see Fig. 15) showed the alluvium at this point to be 510 ft. thick; and the alluvium-breccia contact dipped to the south, indicating the probability that the center or deepest point of the gulch in that locality was farther south. Probably 30,000 or 40,000 gallons of water daily can be obtained from a well such as this; but it is not improbable that after a very long period of drought only those wells which are located in the lower horizons of this underground trough would retain water. The location and dip of the alluvium-breccia contact at other points to the south is shown in the sections, Figs. 6, 7, 8, 9, 10 and 11.

Sinking into the breccia fails to develop more water; and the limestone below it is quite dry. The normal water-level has not yet been reached in the camp, and water is never overabundant.

Towards the southern boundary of the alluvium the feathering-off of both it and the breccia is shown on the sections. The breccia outcrops at the surface in few places only, but is very close to it in the Jesus Maria and Exploradora claims (Fig. 6), and only 70 ft. deep in the Dionea claim (Fig. 9).

The origin and deposition of the breccia have been the subject of much speculation. It is soft and easily worked, and has been considered to be a disintegrated product of faulting. It is more probably a volcanic mud-flow from below the center of the valley, *i.e.*, between the Sierra Mojada and Sierra Planchada ranges. (See Mr. Chism's section, Fig. 1.)

Porphyritic breccias, or volcanic mud-flows, of this character, are common in the north of Mexico. In the lead-mining district of Santa Eulalia, near the city of Chihuahua, northwest of Sierra Mojada, an immense area of limestone is covered with

somewhat similar breccia, which in this latter case forms the summits of the mountains instead of the bottoms of the valleys. In places at Santa Eulalia it is more than 1800 ft. thick. As a rule, the Santa Eulalia breccia contains rounded fragments of limestone, but in some horizons it carries angular fragments of porphyry, at times very similar to the Sierra Mojada breccia. In the rounded limestone pebbles enclosed in the porphyry at Santa Eulalia it is not uncommon to find unaltered fossils, indicating the absence of any great amount of heat during the processes forming the breccia. The matrix of the breccia in Santa Eulalia is highly siliceous, containing glassy feldspar, and resembles a typical porphyry. To the writer it is difficult to account for the presence of feldspar crystals and unaltered limestone fragments in the same rock. But it seems more difficult to consider the Santa Eulalia or Sierra Mojada breccias as other than volcanic mud-flows, which probably have been squeezed upward through dikes, zones of fracture, or other apertures in the limestone. Several such dikes (in all cases without lime or other fragments) have been opened up in Santa Eulalia, breaking through the underlying limestone formation; but in the Sierra Mojada nothing is yet known as to the source of the breccia.

The siliceous breccia of the Sierra Mojada, which lies directly upon the limestone, is intimately connected with the ore-bodies. The contact between the breccia and the limestone is smooth, and carries ore-deposits of value. The most valuable ore-body ever opened up in the camp—the San José copper-stope—was apparently an impregnation of the siliceous breccia with silver chloride and copper oxide. In this, as in all other cases, there was a well-marked wall or plane of demarcation on each side of the ore-body, with a clay selvage or gouge between the ore and the adjoining rocks. In a few places along this ore-body a thin layer of barren breccia would be found between it and the lime; but usually the north wall of the deposit was breccia, and the south wall limestone. In the Dionea mine, from 15 to 16 ft. of the contact between the breccia and the underlying limestone is very much decomposed, although carrying nothing of value. The steepness of the breccia-lime contact in the San José mine is very noticeable, and in the Buena Ventura shaft the lime is cut at a depth of over 600 ft.; but north of this it

gradually assumes a more horizontal position. In the Veta Rica and Dionea mines (Fig. 15) the contact gradually flattens until at the Juarez shaft it is 130 ft. from the surface. In places, the roll or fold is so great that the local dip of the contact is towards the south. In the Veta Rica and Dionea mines (Figs. 8, 9 and 10) this roll or crease of the breccia-lime contact was found to carry ore, while the limestone for a distance of over 100 ft. from the contact was impregnated with silver chloride. Other rolls or folds of the contact-surface, the axes of which run approximately north and south, that is to say, at right angles to the last mentioned folds, have been found by diamond drilling, but hitherto have not been demonstrated to carry ore or give indications of value.

IV. The Ore-Bodies.

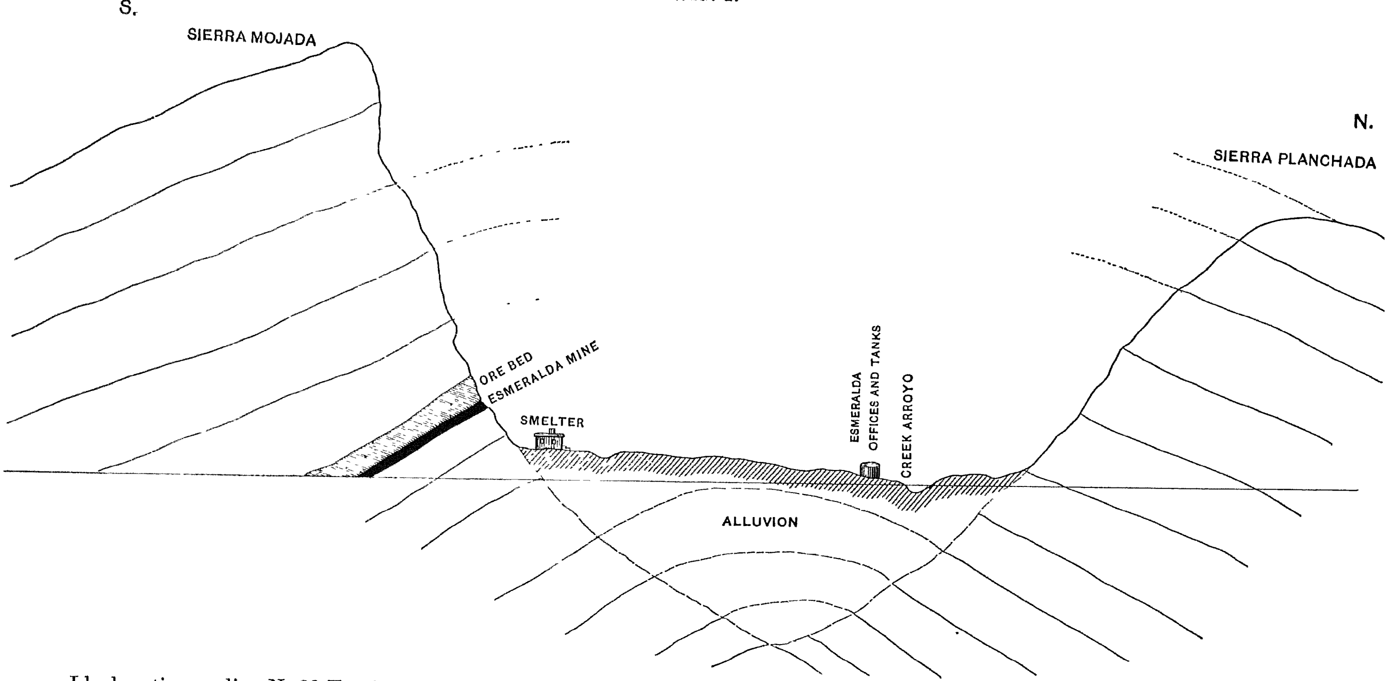
The zone in which the ore-bodies have been found is approximately along an east and west line, and is marked by shading on Fig. 15. The ore-bodies are fairly continuous, and extend for a total distance of over 13,000 ft. from west to east.

The ore-deposits of the camp may be divided into three main groups: (1) the contact-deposits; (2) the lime-impregnations; and (3) the lead-carbonate ores in the limestone. Although the latter were the earliest ores discovered and worked, the breccia-lime contact deposits will here be described first; since the earlier-worked ore-bodies are apparently branches from these deposits, and were the first discovered only because the breccia and conglomerate had been eroded from their vicinity, leaving the lead-ore exposed.

1. *The Contact-Deposits.*

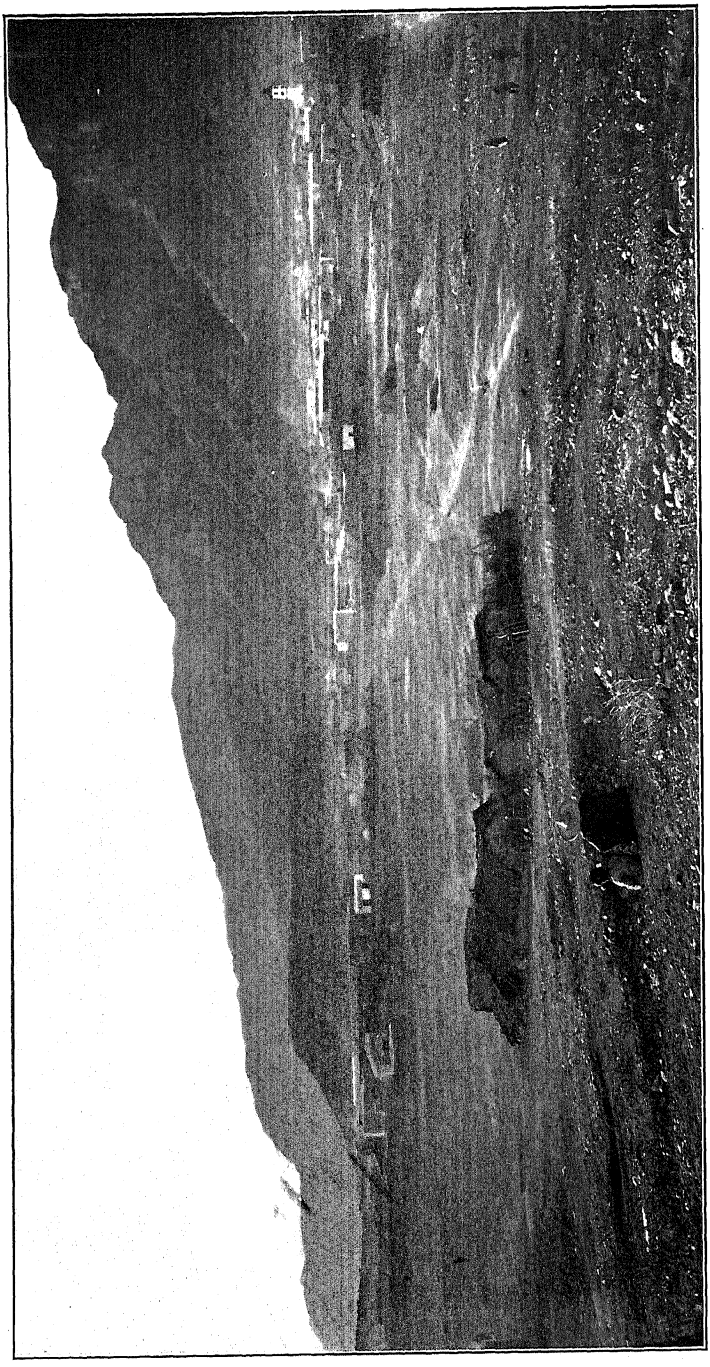
In the Exploradora mine (see section, Fig. 6) a body of lead-carbonate of considerable thickness was found on the contact towards the extreme west of the zone of ore-deposition. The breccia here was apparently unchanged, but a large amount of the limestone had evidently been removed in the process of ore-deposition. After the ore had been mined out, the breccia settled on the square sets and rock-filling to such an extent that a marked subsidence and slip of the overlying breccia took place, the whole mass sliding apparently on the contact surface. From this deposit of lead-carbonate, a very plain vertical crack

FIG. 1.



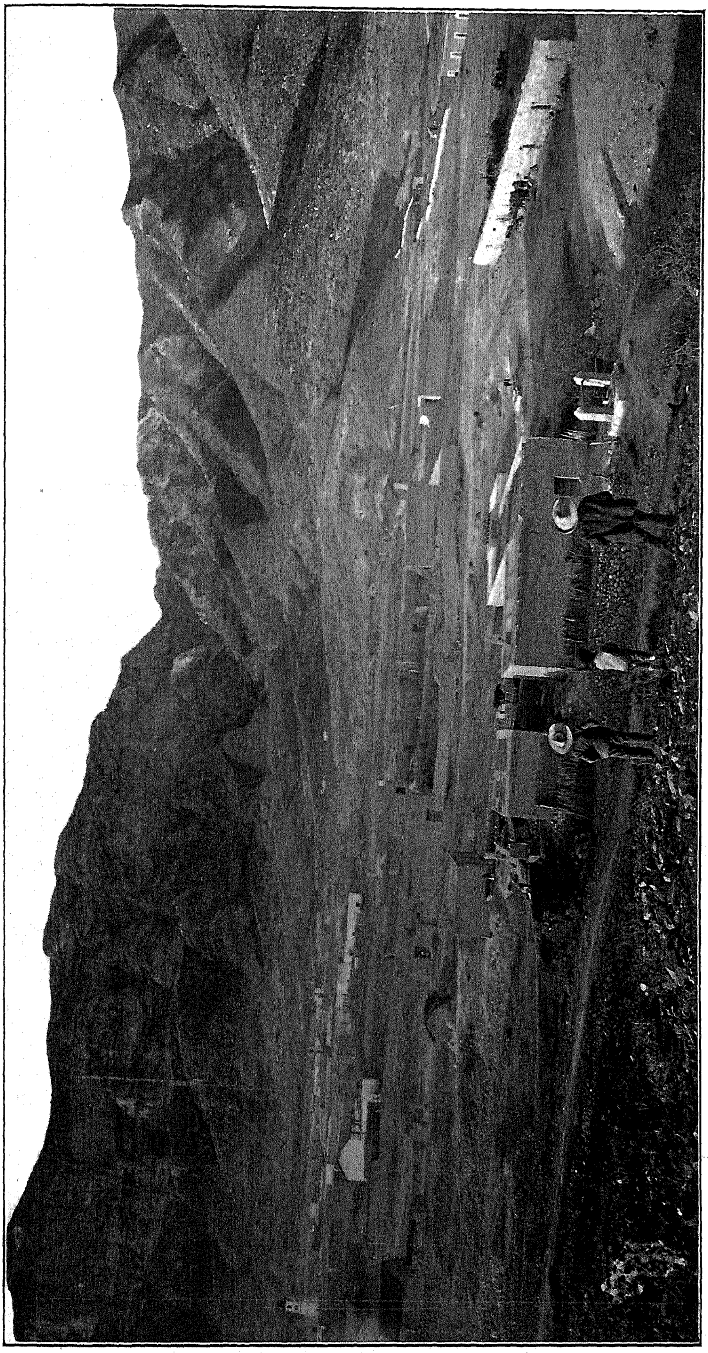
Ideal section on line N. 8° E.—S. 8° W., across Sierra Mojada valley, through the Esmeralda Mine, showing the Anticlinal Break. (Reproduced from Mr. Chism's paper, *Trans.*, xv., 548.) Horizontal scale, 1 : 50,000 ; vertical scale, 1 : 10,000.

Fig. 2.



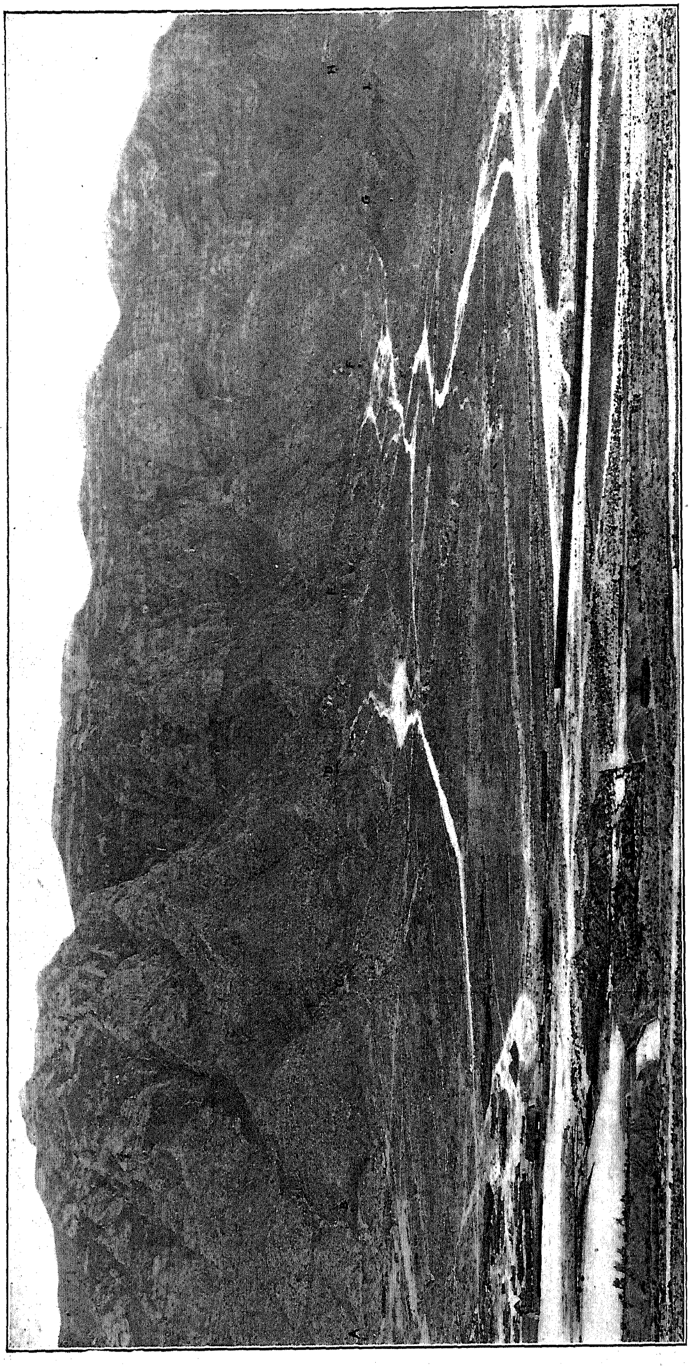
Left-hand Half of View of Sierra Mojada, looking SE. from Town. (See Figs. 15 and 3.) The flat-topped hill just behind the buildings on the left is La Blanca hill, capped with Cretaceous limestone.

FIG. 3.



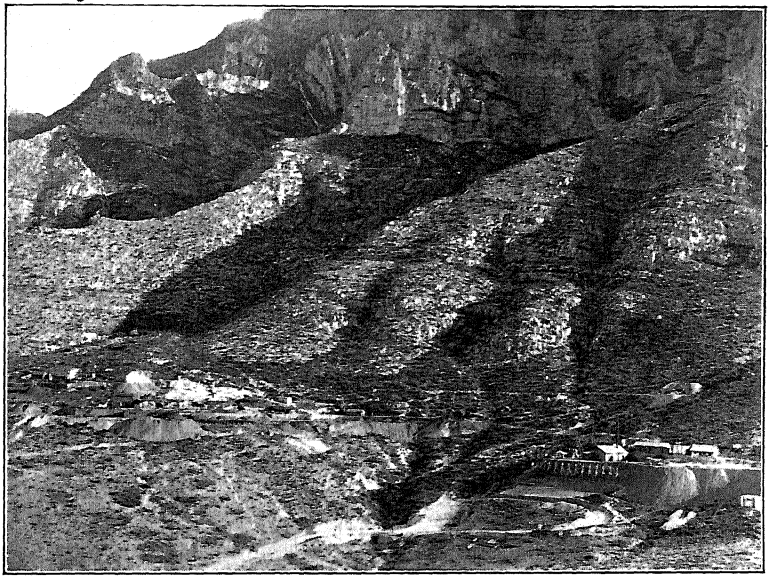
Extension to the Right of Fig. 2. (The tower of the parish church on the left is seen at the right in Fig. 2.)

Fig. 4.



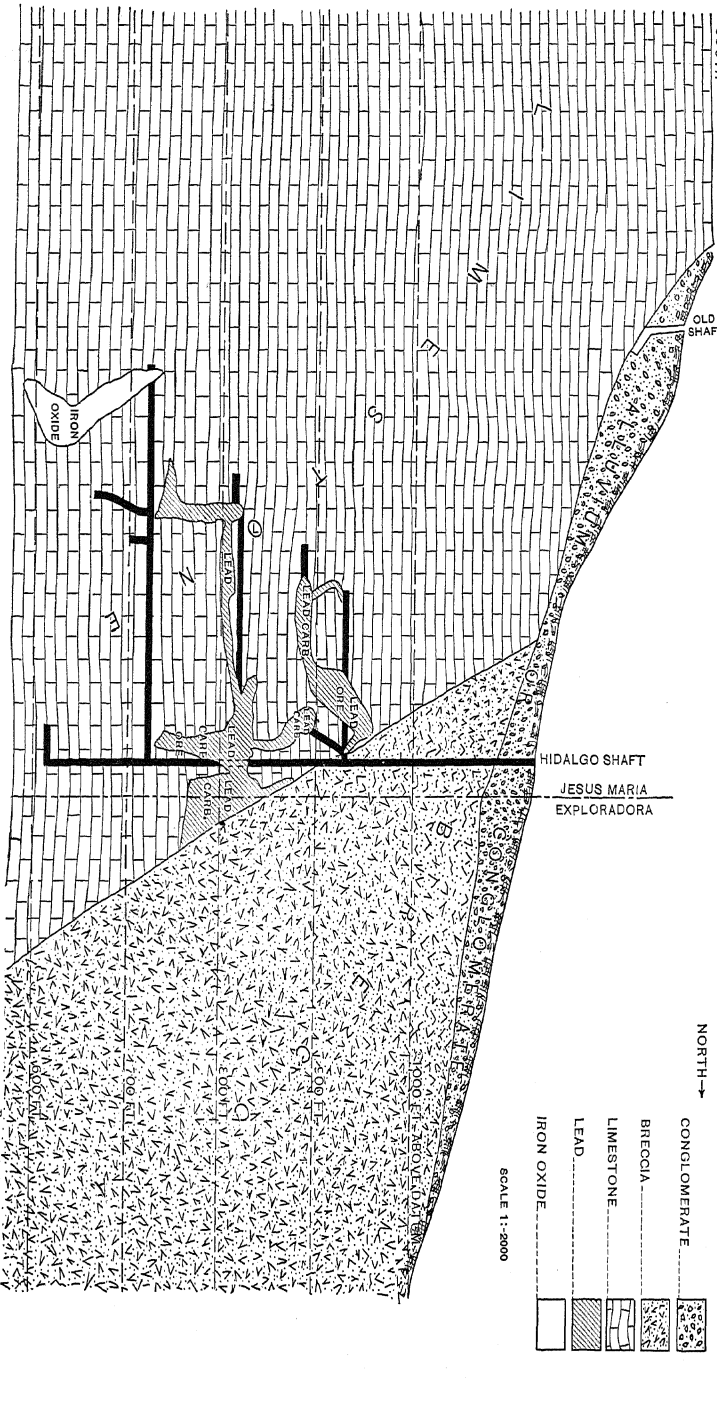
View of Sierra Mojada, looking SW. from El Estanque. (See Fig. 15). Mines: A, San Salvador; B, Esmeralda; C, Dolores; D, San Miguel; E, Providencia; F, Fortuna; G, San José; H, Jesus Maria; L, La Blanca hill.

Fig. 5.



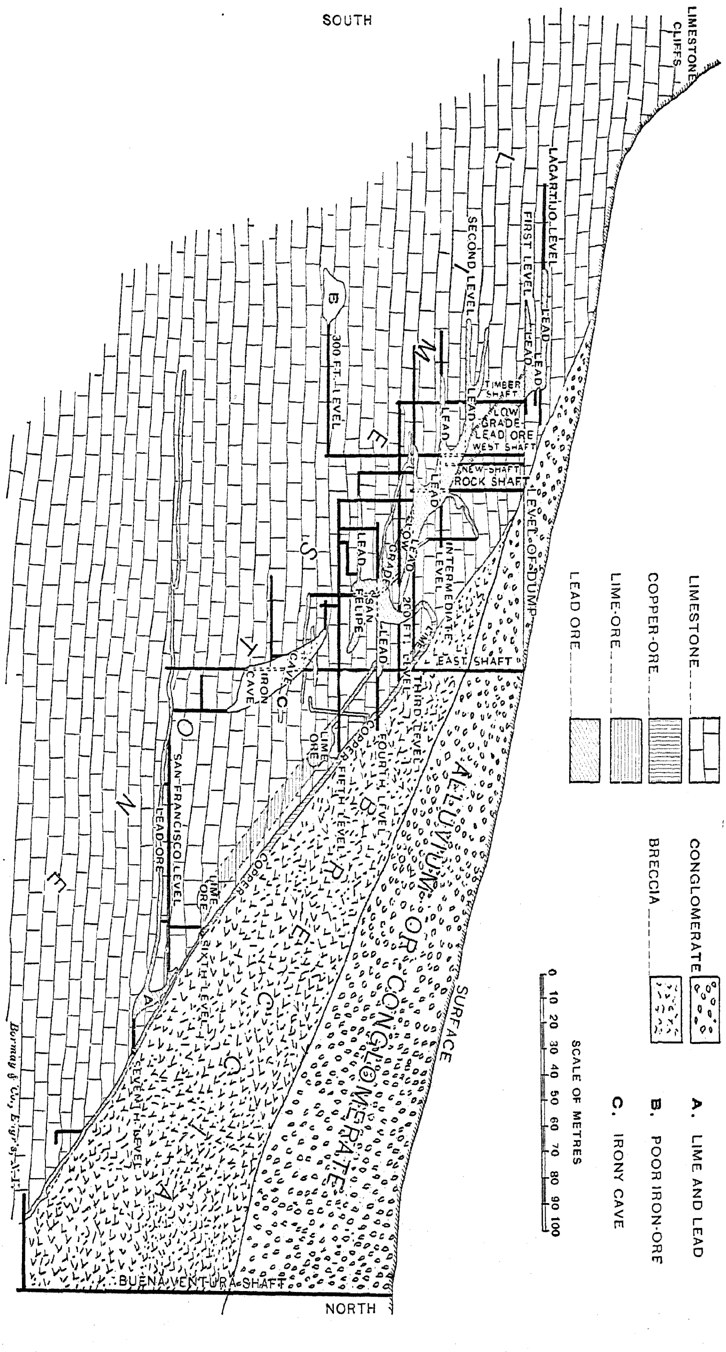
San José and Exploradora Mines, Showing Upturned Limestone Strata Above.

Fig. 6.



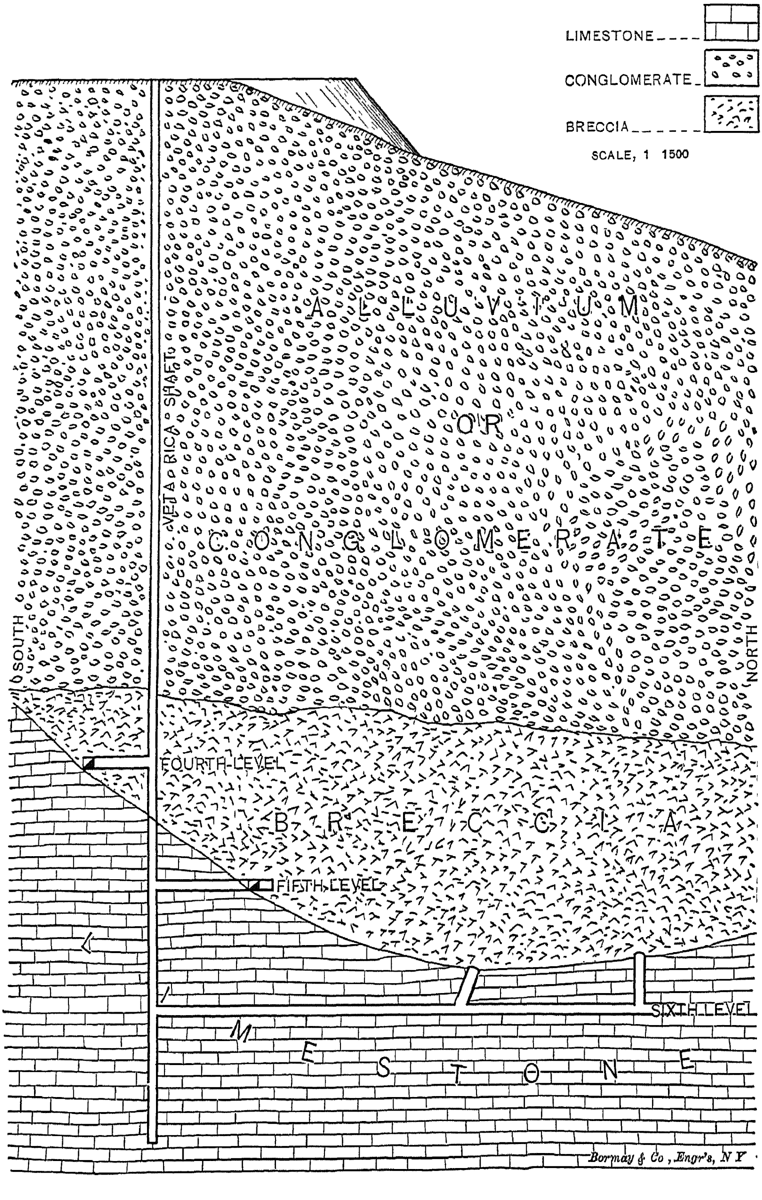
Jesus Maria and Exploradora Mines. N.—S. Section through the Hidalgo Shaft.

FIG. 7.



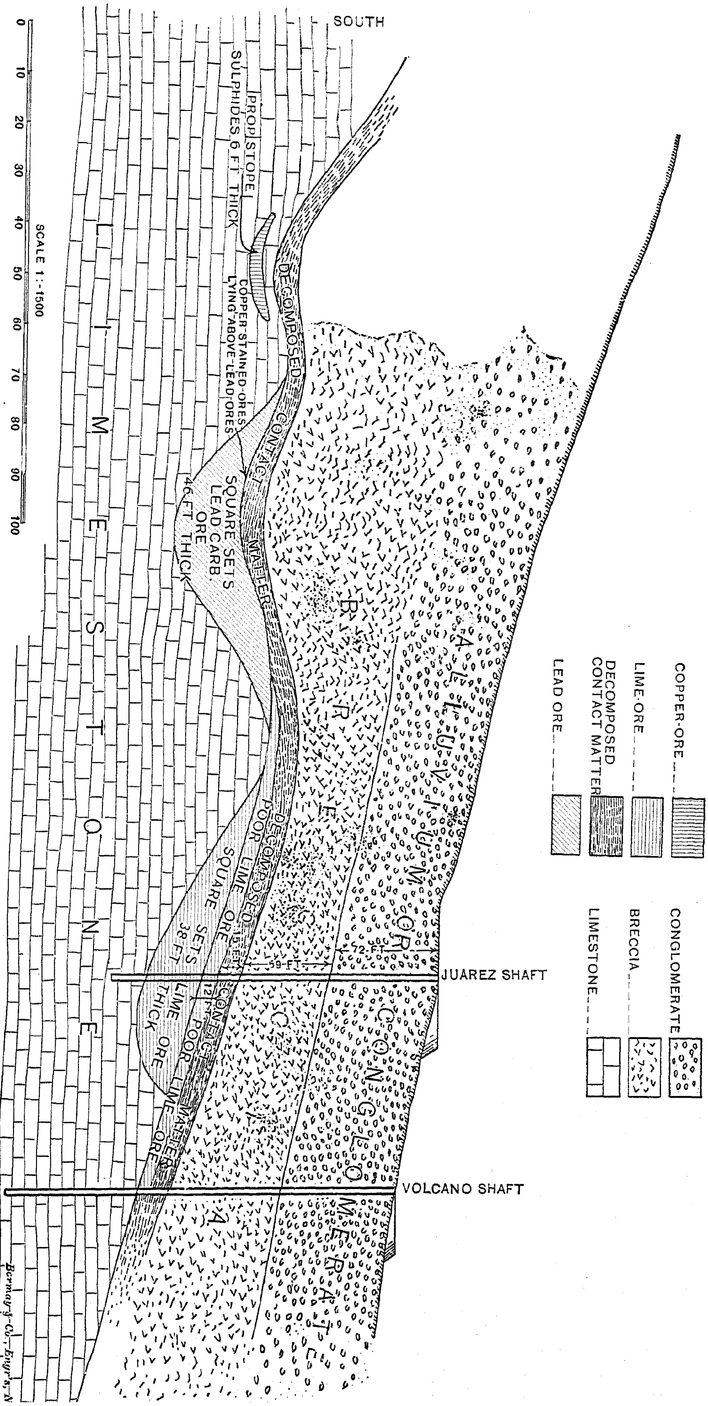
San José Mine, General Elevation, looking West.

FIG. 8.



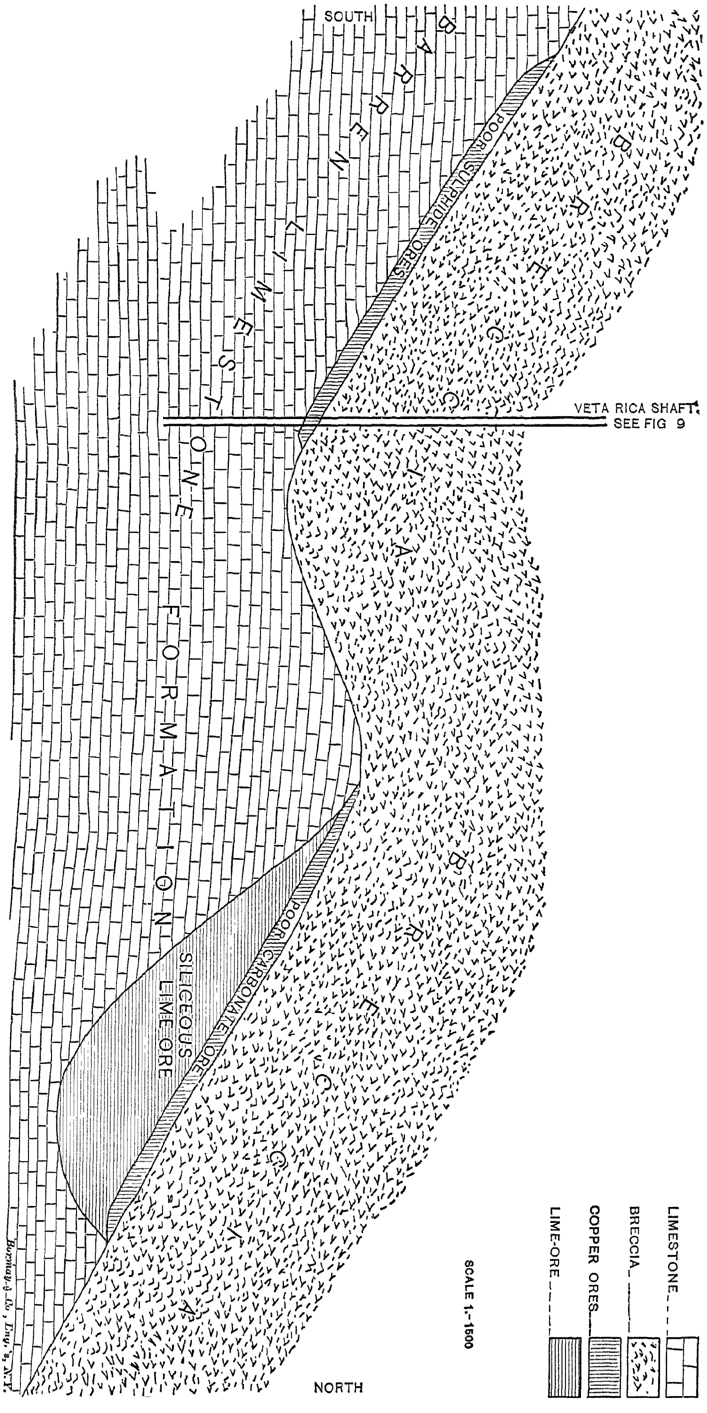
N.—S. Section through Veta Rica Shaft.
(The exact position of the contact between breccia and lime is not known; but it should be higher up than is here shown, and should dip more to the right.)

FIG. 9.



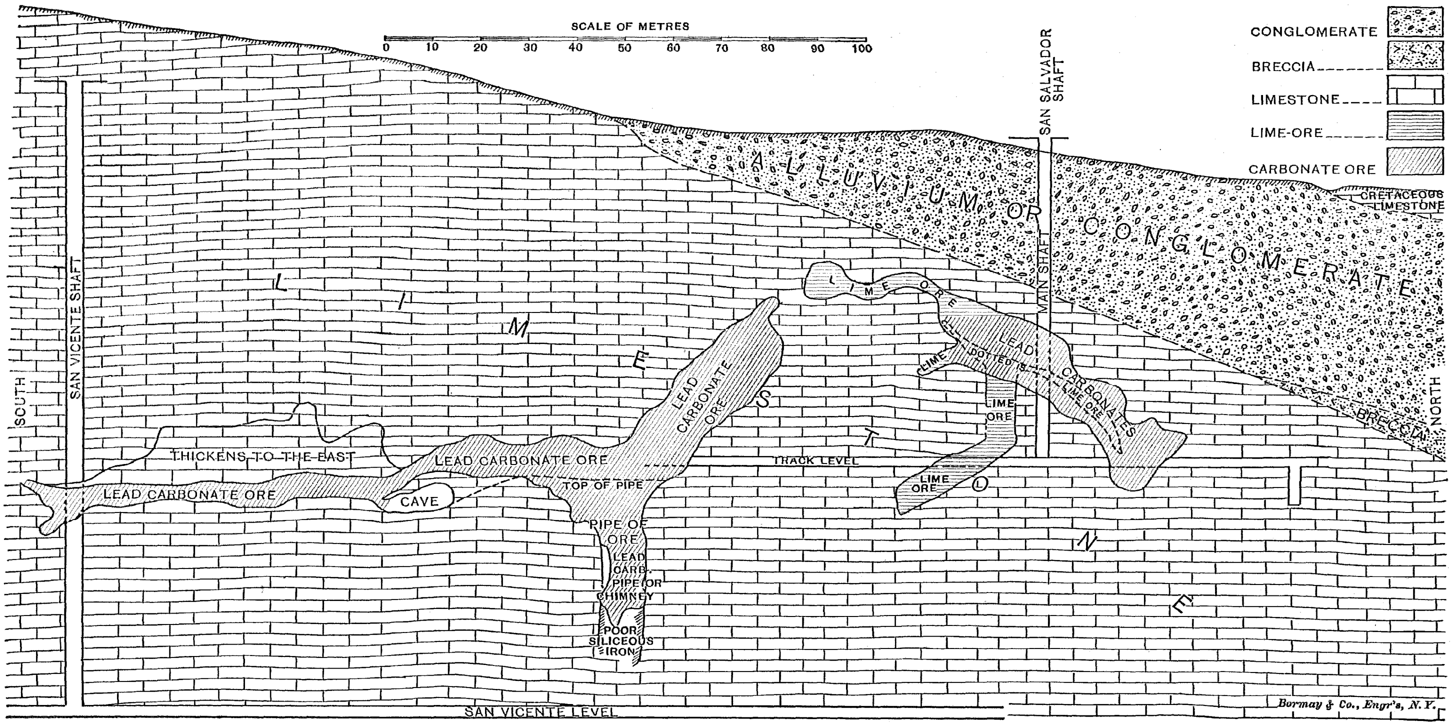
N.—S. Sketch-Section through the Juarez Shaft, Dionea Mine.

FIG. 10.



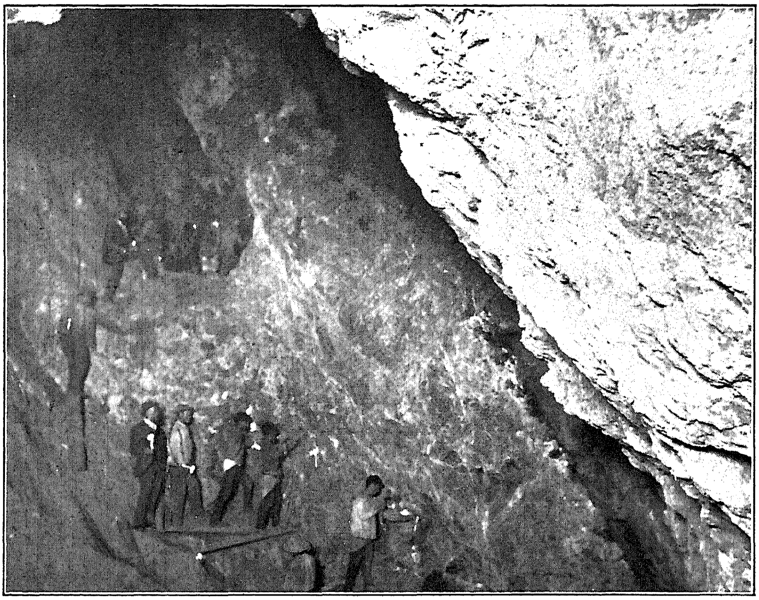
Sketch Showing N.—S. Section of Veta Rica Ore-Body.

Fig. 11.



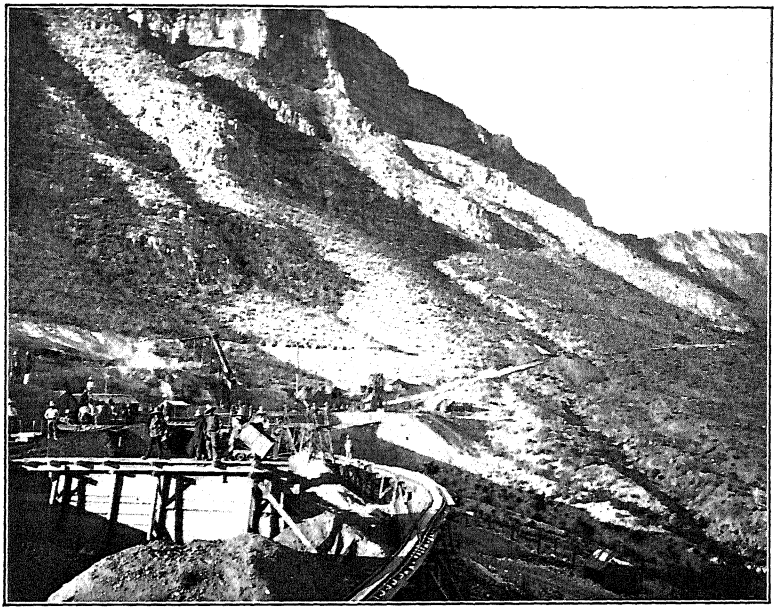
San Salvador Mine. N.—S. Section through Main Shaft.

FIG. 12.



Mining Lime against the Breccia, Veta Rica Mine.

FIG. 13.



The San José Mine in 1899.

FIG. 14.

Old Method of Working. Volcan Dolores Mine.

runs directly to the south into the lime, making a prominent feature of the western part of the Jesus Maria mine (see Figs. 6 and 15).

The crack shows slickensides, although the breccia contact to the north does not appear to be deformed or faulted in any way. This crack is intimately connected with a deposition of several thousand tons of basic lead-carbonate in the limestone, some distance from the contact; and still farther south a large body of iron oxide has been opened up, with very low silver- and lead-values (see Fig. 6). Several of these vertical fissures at right angles to the contact have been prospected. Their origin and importance is still a matter of conjecture. The fissure described towards the west of the Jesus Maria mine is one of the most strongly marked, and it shows ore-bodies related to it in a more noticeable manner than any other. East of the Exploradora lead-carbonate deposit, and between the Jesus Maria and San José mines, an ore-body has been opened on the contact assaying from 15 to 25 oz. silver per ton; 75 per cent. silica; 8 per cent. iron; less than 1 per cent. lime, and carrying traces of lead and copper. This ore-body varies in thickness from 10 to 20 ft.; it is friable and sandy in structure, easily mined, and covers a large area, being found from the outcrop of the contact-surface in the Jesus Maria mine to a considerable depth in the San José mine. The lead-carbonates in the limestone immediately south of this deposit, instead of carrying an excess of iron over silica, as they did to the south of the first ore-deposit mentioned, are siliceous, carrying an excess of silica over iron.

Only a short distance east of the siliceous contact-ore, but at a greater depth, was found the famous San José copper-stope. It is probable that the last mentioned siliceous contact-deposit and the copper-stope form a continuous deposit, changing in character with depth.

The San José copper-stope was the first ore-body discovered on the contact, and is the richest exploited hitherto in the Sierra Mojada. Its dimensions are, roughly, 450 ft. from E. to W., and 530 from N. to S. on the dip of the contact. In thickness it varied from 6 to 20 ft., with a general average of perhaps more than 12 ft. The ore mined from the deposit assayed between 60 and 70 oz. of silver per ton; 4 to 6 per cent. copper;

40 to 50 per cent. silica; 3 to 8 per cent. iron; and 1 to 5 per cent. lime, with traces only of lead.

The discovery of this deposit in 1889 was the cause of a new period of development in the camp. Shafts were sunk at many points to the lime-contact, with the object of investigating a region which had previously been considered valueless; but the result up to the present time has not been so productive as was originally anticipated. Only a few ore-bodies have been discovered, and immense areas of the contact have been demonstrated to be barren. No purely contact ore-body of any size has been discovered that at all approaches the San José copper-stope in either tonnage or grade of output. The section, Fig. 7, shows this contact copper-silver deposit, and its position with relation to the lead-carbonate ore-bodies of the San José mine. Attention is called to the upper part of the copper-deposit, which appears to leave the contact and roll over to the south, where it connects with the lead-carbonate deposits in the lime. This contact-deposit has apparently little or no direct connection with the lead-ore bodies except at this point. Although not shown in the section, there seems to be, in the upper portion of the copper-deposit, a roll or crease in the contact, which may have tended to divert the ore-depositing agencies from the contact into the lime. All these workings are now, unfortunately, so completely run together that it is difficult to secure accurate information on this point.

The San José copper-deposit differs principally from the two previously mentioned deposits in that it is apparently an impregnation of a layer of breccia between the main body and the limestone. There seems to have been no solvent action on the underlying lime, as in the Exploradora deposit, or leaching out of the alumina silicates, as in the second deposit described. The chemical composition and appearance of the San José copper-deposit and the overlying breccia are almost identical. The basic lead-carbonate ore-bodies south of this contact-ore are entirely isolated from it, except at the upper part, as shown, where the copper-stope changes to lead-carbonate and dips south. The deposition of the lead-carbonates appears to be connected in some way with a plane of fracture or shrinkage parallel to, and some 120 ft. S. from, the breccia contact-plane. This plane or zone is observable on the general section of San

José, Fig. 7, and a number of flat lead-carbonate ore-bodies may be seen running between the planes of stratification towards the south, branching from the inclined plane of lead deposition which is parallel to the contact. These two parallel planes, that of the copper-ore on the contact, and that of the lead-ore 120 ft. S., and wholly in the limestone, have given rise to a belief that the copper and lead carbonates represent distinct periods of ore-deposition. Between the zone of deposition of the lead-ore, parallel to but some distance from the contact, and the copper-ore on the contact itself, much of the limestone is impregnated with silver chloride, and from 0.5 to 2 per cent. of copper (see Fig. 7). To the east of the copper-deposit in the San José and Fortuna mines, very little ore has been found on the higher levels of the contact; but NE. of the Veta Rica and Dionea mines the limestone was discovered much nearer to the surface than was originally expected, and extensive prospecting developed the existence of the above-mentioned huge roll or crease of the contact-surface. Mineral of low grade, somewhat similar in character and composition to the San José contact-ore, was found; but the financial result of the exploration was bad for a number of years. Finally in the Veta Rica mine the discovery was made that, although the contact-mineral itself was poor and unprofitable near the vicinity of the roll, the limestone below was impregnated with silver chloride—although at the same time with silica—to such an extent that the siliceous lime could be mined with a very respectable margin of profit. The ore carried, as a rule, 15 to 50 oz. Ag; 20 per cent. SiO_2; 20 per cent. CaO; 10 per cent. $BaSO_4$. A sketch section of the deposit is shown in Fig. 10. In some parts of this ore-body the silver-bearing lime is separated very distinctly from the surrounding barren lime; but in most directions, particularly to the E. and W., there are no definite boundaries to the ore-body.

As mining progresses, the grade gradually becomes so low that it no longer pays to continue operations. Many thousand tons of ore have been mined from this ground, assaying from 15 to 40 oz. Ag; 10 to 20 per cent. SiO_2; 20 per cent. CaO; 3 per cent. Fe; and 1.5 per cent. Cu, with no lead.

2. *The Lime-Impregnations.*

The finding of lime-silver ores below the contact of the breccia aroused renewed interest in prospecting, not merely along the

contact itself, but down into the limestone; and latterly, NE. from the Veta Rica mine, in the Tiro 11, Dionea, and Tiro 10 ground, a limestone-deposit of considerable size has been opened up, several hundred feet in length and in cross-section as shown in Fig. 9.

Here two rolls in the breccia contact were found, one a few hundred feet north of the other. The axes of these rolls are roughly east and west; and they seem to be a north-easterly continuation of the roll previously found in the Veta Rica mine.

In the northern roll, in the Dionea mine, the Juarez shaft was sunk through 72 ft. of calcareous conglomerate, 59 ft. of siliceous breccia, and 16 ft. of decomposed contact-matter without value, to solid barren lime. Sinking being still continued, the rib of barren lime proved to be only 13 ft. thick; and impregnated lime was discovered below it, assaying from 30 to 60 oz. silver per ton, with 15 to 20 per cent. silica. The Veta Rica deposit (Fig. 10) is of a somewhat similar composition. In the Dionea mine the southern roll contained, in the lime below the contact, siliceous lead carbonates, assaying from 12 to 15 oz. silver per ton, and 15 per cent. lead, with an excess of silica over lime.

The silver-lime impregnations are now of greater importance than the contact-deposits. They are divided into two classes: (1) those near the breccia contact; and (2) those far from the contact, in the vicinity of the lead-ore deposits. The first class (near or adjoining the contact) are found W. of the contact, in the San José, Veta Rica, Tiro 11 and Dionea mines. These ores usually carry 20 per cent. CaO; from 15 to 20 per cent. SiO_2, partly existing as silicate of alumina; and barium sulphate from traces up to 12 per cent. Iron and zinc are found in small quantities (not above 3 per cent.); and most of the ore carries copper, seldom exceeding 2 per cent., but perhaps averaging 0.5 per cent. The silver is found as chloride. Apparently this limestone has been impregnated and silicified from the contact, through the leaching of a contact-deposit and its dissemination throughout the adjoining limestone. It is an interesting fact, however this may be, that the impregnated limestone near the siliceous copper-deposit on the contact presents some features in common with the contact-deposit itself. In

this respect the large amount of decomposed and barren contact-matter found in the Veta Rica and Dionea mines is worthy of notice. In other parts of the camp, where no silver-lime impregnations exist, there is a marked absence of this altered and decomposed barren contact-material.

In the general section of San José shown in Fig. 7, a lime ore-body 30 or 40 ft. from the contact is shown. This deposit, which is of immense dimensions, is separated from the overlying copper-stope by 40 ft. of barren limestone. The copper-stope contained from 4 to 5 per cent. of copper and 60 to 80 oz. of silver per ton, and apparently had not been impoverished to any notable extent. The condition of the silver-lime ore-body here is an interesting commentary on this observation. It assays from 4 to 12 oz. of Ag and from 40 to 50 per cent. CaO, with traces of copper and only 3 per cent. SiO_2. It is practically a pure carbonate of lime, slightly impregnated with silver and little or no silica. The siliceous lime is dark-colored and easily distinguished from the barren lime. The San José limestone last mentioned is quite indistinguishable from the barren lime formation. Indeed it is only by constant vigilance and care that it is possible to mine the ore at all. It is necessary to take daily, from all working-faces, samples of large size for assay; and even with this precaution it is not uncommon for lots of considerable size to be mined at a loss, on account of an unexpectedly sudden change in the assay-value. The boundaries of the silver-lime deposits are at times very plainly marked by walls separating the barren lime from the impregnated lime; but usually such boundaries are not reached in mining, because the grade falls to an unprofitable limit, which varies with the silica-contents of the lime. It is common to find ribs and irregular masses of quite barren lime running through good stopes, with well-marked walls and good ore on both sides. There seems to be no general direction to these barren zones; sometimes they are parallel, and sometimes at right angles, to the stratification. The lime ore-body previously described, S. of the copper contact-ore in San José, is entirely separated from it by a rib of barren lime; and it is not likely that these silver-contents were derived from the contact,—at least not likely that they came from its upper levels. This lime was originally discovered by following a fissure containing lead car-

bonate downward from the 4th level, 120 ft. from the contact. (See Fig. 7.) The lead-ore contained a large percentage of barium sulphate and silica, and changed in depth to very low-grade iron oxide, which finally disappeared, leaving only fissure-walls. In this fissure, parallel in strike and dip to the contact, sinking was continued in barren lime until near the 5th level. Here the lime was charged with silver chloride; and there can be but little doubt that this impregnation came from the fissure, or others parallel to it, which perhaps at a deeper level run toward the breccia-contact. A cross-cut was driven from the copper-stope at the 6th level, 200 ft. below the 5th (Fig. 7), with the result that the silver-lime was again found, with 45 to 50 per cent. of lime, so that the presence of a large area of silver-bearing limestone was thereby demonstrated.

The second class of silver-impregnation in the limestone (those found near, and associated with, the lead-ore bodies) are found towards the eastern part of the camp, and have been principally worked in the San Salvador mine. Their general relation to the lead-ore bodies and to the contact, which is here almost everywhere barren and unaltered, is shown in Fig. 11. There are here two classes of ore, found respectively in the upper and in the lower levels of the lead-deposits. The upper lime-ores usually contain 20 per cent. of lime, and in addition carry 10 to 30 oz. Ag; 3 per cent. Pb; 3 to 8 per cent. SiO_2; 8 to 10 per cent. $BaSO_4$; 5 per cent. Fe and 5 per cent. Zn. In this ore the silver, existing as chloride, seems to be in the interstices of the smaller joint-planes of the lime, and for that reason it is sampled with difficulty. In screening the ore, the fines usually assay 15 to 20 per cent. higher than the coarser fragments. In the lower grades an attempt was made to utilize this fact by screening the broken ore, using the larger and poorer fragments for mine-filling and shipping the fines. This peculiarity has not been observed in any of the other limes, and least of all in those grades where the lime-contents are exceptionally high. In these latter cases, the silver chloride seems to be uniformly disseminated throughout the whole of the lime-rock; and, after screening, the fine material assays the same as the coarse.

The lime-ores found in the regions of the lower levels of the lead-stopes are high in lime (usually over 35 per cent. CaO) and

seem to be, to a great extent, deposited as an ore-body of approximately regular shape, with fairly well-marked boundaries. (See Fig. 11.)

The lime-deposits in San Salvador show in places well-marked faults, along approximately N. and S. planes; and the presence of barren patches of limestone is very plainly observed. The character and mode of deposition of these ores in the eastern part of the camp is still very imperfectly understood; they run low in both silver and lime; and it is difficult to mine them with a margin of profit.

3. *The Lead-Carbonate Deposits.*

The contact-deposits and the allied lime-silver impregnations beneath them, though scientifically interesting and economically valuable, are of minor importance compared with the lead-carbonate ore-bodies found wholly in the main limestone formation.

The Sierra Mojada has always been regarded as a source of lead-supply; and to-day probably two-thirds of the entire product of the camp is lead-carbonate ore from these last-mentioned deposits. The average assay of the lead-ore, now mined at the rate of 120,000 tons annually, shows approximately 12 oz. of silver per ton and 15 per cent. of lead. At several points the lead carbonate outcropped at the surface with nothing to obscure its presence; and a large number of the ore-deposits now worked were opened up very soon after the original discovery of the camp. A comparison between Mr. Chism's section (Fig. 1) and the general section of the San José mine (Fig. 7) shows the result of the fourteen years' work done since Mr. Chism's paper was written. The lead-ore deposits are everywhere oxidized, and carry varying percentages of iron and silica, according to their respective locations. Between the San José and Jesus Maria mines the lead-ores found near the silica-contact ore are also siliceous in character, containing an excess of silica over iron. In San José generally, the lead-ore bodies deposited along the before-mentioned plane, parallel to and 120 ft. S. of the breccia-contact, are high in silica (containing, as a rule, 20 per cent. SiO_2, with a small excess of iron); but as the ore-bodies are opened up toward the south and farther from the contact, the silica is gradually diminished and

the iron increased. In the Lagartijo lead-stopes (the farthest from the contact in San José: see Fig. 7), the iron is usually from 50 to 60 and the silica from 3 to 5 per cent.

In San Salvador (Fig. 11), in the east part of the camp, the northern ore-body contains from 20 to 25 per cent. SiO_2; 10 to 20 Fe; 20 $BaSO_4$; 3 CaO; and 5 Zn. The southern and principal ore-body contains 10 per cent. SiO_2, with from 25 to 50 iron oxide, and little or no barium sulphate. In the Volcan Dolores mine, on the contrary, the section of which is similar to that of Esmeralda, as shown on Mr. Chism's sketch (Fig. 1), the southern part of the ore-deposit is more siliceous than the northern, offering thus a marked contrast to the previously-mentioned cases.

The lead-ore deposits are practically continuous along the foothills of the Sierra Mojada range for more than 2.5 miles from E. to W. Towards their western extremity, in the Exploradora mine, they are found at or near the contact of the lime and breccia; but towards the E. they gradually recede from the contact, until, in the Fronteriza mine, they are a long distance S. of it.

Figs. 1, 7, 6, 11, 9 and 10 show sections of the ore-bodies in the Esmeralda, San José, Exploradora, San Salvador, Dionea and Veta Rica mines respectively, and give a fair idea of the changing character and shape of the deposits.

The lead-ore bodies follow to a limited extent the planes of stratification of the limestone, which is nearly horizontal in San José and Jesus Maria, but much steeper near the Volcan mine and in the Esmeralda ground. (See Mr. Chism's original sketch, Fig. 1.) As a whole, the formation dips slightly SE., and the lead-ore deposits, towards their eastern limit, are more than 1000 ft. below the surface. In the San José mine, the zone of alteration and apparent faulting or disintegration of the limestone, previously described, S. of the contact and parallel to it, has yielded an immense quantity of lead carbonates, which had been deposited in the zone of disintegration.

The horizontal ore-bodies, or sheets of ore, extending southward from this zone have also supplied for many years a large tonnage of lead carbonates annually. In the upper level of the San José mine, where the limestone outcrops at the surface, the isolated horizontal deposit known as the Lagartijo (Fig. 7)

has been found. Its connection with the zone of deposition mentioned above as lying parallel to the contact has evidently been removed by erosion. The ore-body shown in Mr. Chism's sketch (Fig. 1) is of a similar character, and was at one time connected with a deposit farther north, either on the contact or along the zone of disintegration described. In this latter case the limestone strata dip more rapidly towards the south. Mr. Chism's sketch shows the nature of the San Miguel, Volcan and Dolores lead-deposits, which dip to the south like the Esmeralda deposit.

In the eastern part of the camp, at the San Salvador mine, work has been carried on, since the discovery of the camp, in an ore-body lying some distance S. of the contact. Along the western boundary of San Salvador the ore outcrops at the surface in a creek-bottom; and it is continuous eastward throughout the whole of the mine, gradually receding from the contact and appearing at greater depth. From the E. boundary of Salvador it extends through the Encantada, and a considerable distance into the Fronteriza mine, attaining a total length of 4500 feet. On the Salvador-Encantada boundary it is 450 ft., and on the Encantada-Fronteriza boundary 750 ft., below the surface.

A noticeable peculiarity in the eastern part of the camp, particularly in the Salvador mine, is the presence of a shattered and completely broken-up limestone roof over the lead-carbonate ores. This shattering appears to have been due to the collapse of the enormous roof after the reduction in bulk of the ore-body, due to oxidation. This disintegration is in places so complete that the lime, over a considerable area, is made up of small angular fragments, which sometimes run into the stopes like very coarse sand.

Low-Grade Ores.—In addition to the ores actually mined, all the ore-bodies contain immense quantities of low-grade material and iron oxides. The sections show simply the shape of the ground as mined, and do not accurately show the size and extent of the complete deposits. The higher-grade ore is not by any means continuous throughout the ore-deposits; and as cheaper mining and lower freight- and treatment-rates permit poorer ore to be handled with profit, it has been not uncommon to find large and valuable ore-bodies of great size, which were entirely overlooked when the ground was first prospected. In

several of the mines ore-bodies of considerable size have been opened up, years after careful exploration, two or three times renewed, had been made, in poor vein-matter only a few feet away.

The Sierra Mojada ore-bodies, like most of the lead-ore deposits in limestone in northern Mexico, appear to have been completely oxidized. They are usually roughly horizontal, forming interstratified ore-sheets varying in thickness from 2 to 40 ft. Pipes or pendant columns of ore are often found, extending from the floor of the normal ore-bodies downward to a depth of sometimes 200 ft. These chimneys are more common towards the eastern part of the camp than elsewhere. One of them is shown in the section (Fig. 11) of the San Salvador. They often contain from 5000 to 10,000 tons of lead-carbonate ore in their upper portion; but as depth is increased the contents gradually change, until very little lead or silver remains, ores of these metals being replaced by low-grade siliceous iron oxides. These, in turn, gradually pass into siliceous clay, below which the unchanged limestone is found in all directions from the bottom of the hole or pipe. In some of the lower levels of the mine, masses of zinc carbonate have been found; but the presence of zinc sulphide is nowhere prominent. No gold is found in any of the mines. In the lead-deposits, very pure lead carbonate is often found associated with large masses of native sulphur and gypsum, both very pure. The segregation is so noticeable that pure gypsum is looked upon as a valuable indication of the proximity of ore. Many car-loads of native sulphur have been shipped to the United States for chemical purposes; and much more has been burned off from the ore in open piles, to make the grade of the lead-carbonate residue high enough for profitable shipment.

Sulphides are encountered in small quantities, usually around the boundaries of the ore-deposits. In the deepest ore-bodies hitherto discovered in the camp (in the San José and Fronteriza mines), there is no appreciable increase in the relative quantity of the sulphide-ore.

V. Methods of Mining.

1. *Early Methods.*

For a number of years after the discovery of the Sierra Mojada the ore was mined by a pillar-and-stall method, poorly adapted to ore-bodies showing such marked irregularities in roof and floor, and, at times, such large dimensions in every direction. In several instances, although the ore-bodies were fairly well exposed, the whole mine had become dangerous to work before 20 per cent. of the ore in sight had been extracted. The Mexican owners and operators finally reached a point where they were no longer sure of being able to continue operations. At that time the use of lumber was almost unknown, and its very great cost was considered as prohibitive. The following description of the mining methods employed in 1886, taken from Mr. Chism's paper,* gives a very good idea of these old methods:

"In working the mines, no mechanical appliances of any kind are used except picks and crow-bars. The ore tumbled down in the working-faces by bars and picks is shoveled with the bare hands, or perhaps with a horn spoon, into leather bags, which are brought to daylight on men's backs [Fig. 14]. Here the ore is weighed and delivered to the pickers, who separate the dirt and native sulphur from it and sort it into grades. . . . . In the underground work little effort at regularity is made. The workings follow the richest streaks of the deposit, leaving irregular pillars surrounded by tortuous passages, which now and again open into large chambers. There are no proper stopes, all the workings being in reality headings. Descents from one level to another are generally made by the usual notched sticks. . . . . Timbering has been resorted to in many places, but not to the extent one might expect; and it is often lacking where safety most imperatively requires it."

It must be admitted that these early methods, which were chiefly confined to following the best ore-streaks, were very successful in discovering and opening up a very large portion of the ore. In several of the mines very little ore has been discovered which was not originally opened up by the first owners; subsequent economies and successes having been effected by more efficient methods of handling and treating the ore. The isolated deposits, however, and the contact-de-

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* *Trans.*, xv., 552.

posits not outcropping at the surface, have practically all been discovered in later years, since the older methods of prospecting did not include cross-cutting and driving in barren ground for purposes of investigation.

2. *Modern Methods.*

Shortly after Mr. Chism's description was written, in 1887, an American corporation, the Consolidated Kansas City Smelting and Refining Co., undertook to work several of the mines, under lease from the owners. Texas lumber was shipped into the camp, *via* Escalon on the Mexican Central R.R., 75 miles away, at a cost, laid down at the mines, of $40 to $45 U. S. currency per 1000 ft., board measure. Square-set methods of mining and timbering were introduced. Experienced timbermen from Colorado were employed at first to put in the sets; but the Mexican miners themselves finally became so skillful that of late years practically all the timbering has been done by native labor. A few years after taking over the mines the American operators built from Escalon to the camp a railroad, which has been one of the most prosperous enterprises in the Republic.

With the introduction of American methods of mining, it was found profitable to re-work the old and but partially-exhausted stopes throughout their entire extent. On account of the large size and the softness of the lead-ore bodies, the cost of mining has always been low; and by the introduction of square sets of timbering, carefully filled with rock, the old workings have been kept accessible to a remarkable degree. In the eastern part of the camp the limestone roof over the lead-ore deposits was found to be completely broken up and disintegrated, resembling in its treacherous character an overlying quicksand. In timbering up to this roof the greatest vigilance was required to prevent a "run," and, in spite of all precautions, a large amount of sandy limestone would often find its way through openings between the timbers. In some instances, men were buried and suffocated by such irruptions of lime-sand; to prevent which, a thin crust of lead-carbonate ore was, at times, left to assure the solidity of the roof. Recently nearly all this ore has been extracted. Square-set tim-

bering is now very generally employed in the extraction of the ore. The criticism has been made that "caving"-methods should have been inaugurated, and the opinion has been expressed that if a system of regularly caving the roof of the lead-ore deposits had been adopted, instead of the rock-filled square sets, an increase in both safety and economy might have been effected. Subsequent work, however, has completely vindicated the advantages of the square-set method of timbering for this ground. Since the earlier operations, when only ore of much better grade was mined than is the case to-day, it has been found possible to re-work with profit (in some instances three or four times) the ore-bodies in all the mines, because they contained immense quantities of mineral of lower grade than could have been utilized at first, which successive reductions in freight- and treatment-rates gradually rendered available for profitable extraction. Under the "caving" system these low-grade bodies would not have been economically accessible.

In many of the stopes the square sets had been filled, not with lime-rock from the surface, but with low-grade ore from the old workings; and in many cases this filling has been entirely removed and shipped. Moreover, the square-sets, though often crushed and to a great extent demolished, have always permitted exploration work around them in all directions, and the ground has been re-worked at a price, and with a facility, which would have been impossible had it been permitted to cave.

The first tiers of sets were laid on the lowest profitable horizon of the stopes; and the timbering was gradually carried upward in a series of vertical slices toward the roof. When the whole area of the ore-body had thus been gradually and completely mined (in some cases over a horizontal extent of 10 acres, and with more than 24 sets from floor to roof), the whole superincumbent weight of limestone had to be supported. It was only by careful and thorough rock-filling that security was obtained and collapse prevented. Since then, much ore of profitable grade has been discovered to be below the old square-set stopes, and thousands of square sets have been sunk from the old sets by "hangers." To-day, no difficulty is

found in safely mining an ore-deposit of hard or soft ore lying directly under a worked-out and filled stope, where the overhead pressure is very great indeed; and the additional quantity of timber required is very small. The method employed is to sink one line of sets vertically to the lowest point where stoping is to be re-commenced. These sets are suspended from 10 by 10-in. beams, 16 ft. long, reaching over three or more sill-pieces of the old sets. The new sets to be sunk are hung from these beams by pieces of 3 by 6-in. lagging nailed to the new sills, and the overlying 16-ft. stringer. After the new floor is reached (which may be 6 ft. or 60 ft. below the old floor), new sets are thrown out horizontally, using the initial column or columns of suspended sets with hangers, as winzes or manways. The new sets are started in the usual way, being filled with rock, and gradually tied up to the old upper sets as the work proceeds. The San Salvador mine (where over one million tons of ore has been mined from what is practically one continuous ore-body) and the lead-ore deposits in the San José have all been re-worked once, and in some cases two and three times, a large proportion of the output having been obtained by re-opening and continuing in every direction old, square-set stopes. It is certain that much of this ground could never have been cheaply prospected and re-examined, and thereby made available, under any other system of timbering.

Mining the Lime-Ores.—The last-mentioned method is employed in the mining of soft lead carbonates, often sandy in character, and usually with a soft roof or floor, or both, composed either of low-grade iron oxides or rotten limestone. In mining the lime-ores an entirely different proposition has to be faced.

In the lime stopes, which are always hard, very large chambers, 60 by 100 ft. or more, can be opened up with safety (Fig. 12). Finally, however, it is found desirable to support the roof on account of the very large area exposed. The distance from the floor to the roof exceeds, at times, 75 ft., and attempts have been made to support the latter by a large number of 12 to 14-in. posts, filling in the spaces between the posts with waste rock, as the roof is gradually stoped away. A space of from 6 to 8 ft. is left between the ore in the roof

and the filled floor. As the posts are gradually buried, new ones are placed upon the old ones or upon the rock-filling, and the roof is carried upwards. This method has not proved altogether satisfactory, and is now seldom employed. The floor of the stope is usually not absolutely barren, but simply is of too low a grade to be mined. Later, when it is desired to prospect or work below, to obtain information, the ground filled by this method is much less accessible and more costly to reopen than a stope filled with square-sets. For this reason square-sets are generally employed in the lime-stopes, although they are not usually put into place until the stope is of large size. A large number of sets are then put up at once, from floor to roof, and solidly filled with waste rock. The space around the margin of the stope is usually left open for sampling. The square-sets are used here as a holder or framework for the column of waste rock which supports the roof. As the lime-ore is usually of low grade, leaving a very small margin of profit for mining, it seems a pity to spend for timber 75 cts. U. S. currency per ton of ore mined; but hitherto no more desirable method has been suggested which will compare with this in efficiency.

Prospecting.—In the lead-ores lying completely in the limestone, prospecting is almost unnecessary. An immense sum of money which has, indeed, been spent in driving in barren lime, looking for lead-ores, has simply been thrown away; since the ore found has finally proved to be a part of some deposit already worked some distance away. The time-honored maxim which advises the miner to "stay with his ore" applies with great force in this locality. The reductions of recent years in freight- and treatment-rates have enabled ore to be mined at a profit which could not be touched before; and this has been the principal factor in maintaining the prosperity of the camp. The mining of low-grade deposits has resulted again and again in the discovery of ore-shoots of higher grade, entirely separated by zones of low-grade mineral from the deposits formerly worked. This is a very encouraging feature attending the mining of low-grade fluxing-ores, which in themselves leave only a minimum profit to the miner. In such ground there is no better way to expend money on investigations than to follow

the low-grade shoots of iron oxide, fissures or cracks in the lime, or the numerous caves that are continually discovered in the vicinity of the ore-bodies. Large bodies of gypsum are also frequently met near the lead carbonates, and are considered to be guides worth following.

The lime-ores are much more difficult to prospect than the other classes. Even when found near the contact, they are often separated from it by a rib of barren lime several feet thick. The lime-impregnations are often suddenly faulted or cut off by strips of barren lime-rock, sometimes only a few feet thick, after which the ore is again encountered. These slips often cause the abandonment of a stope for several months, until work in other stopes gradually opens up ground in the vicinity and shows the direction of the lost ore-shoot. There is often nothing in the appearance of the lime-ore to indicate whether it is of high-grade in silver or quite barren, and vigilant daily sampling and assaying is necessary to maintain the grade and tonnage of the output.

Prospecting the Contact.—In several of the older mines the contact has been carefully and systematically explored by a series of levels and winzes, analogous to the methods of ordinary vein-mining; but towards the northern and eastern portion of the camp it is still almost entirely unexplored. A large number of diamond-drill holes have been sunk through the conglomerate and breccia to the lime-contact, and at times into the lime below; but the total result up to date has been of a negative character. In spite, however, of the barren result of drilling-operations, it is impossible to doubt that large ore-bodies will yet be found on this contact-plane by further exploration.

Eastern Extension of the Ore-Zone.—Towards the eastern part of the camp a lead-carbonate deposit, wholly in the limestone, assaying 5 oz. silver; 20 per cent. lead; 40 per cent. iron; 3 per cent. silica; and 5 per cent. zinc, has been opened in the Fronteriza mine, at a depth of 800 ft. The relatively small area of this body and its great depth lead the writer to believe that, beyond this mine, the chances of profitable mining operations upon it are not good. In the future the mines with lead-carbonate deposits on or near the contact will probably find

extensions below their present lower levels, since these bodies run southward more or less horizontally, and there is nothing yet to indicate the absence of ore-deposits at lower levels than those now exploited.

Hoisting.—In nearly all the mines the ore is hoisted to the surface through vertical shafts, some of which have noticeably small dimensions (one being 3 by 4 ft. inside the timbering). In the Dolores mine, where the ore is in a flat sheet, dipping S., it is hoisted up an underground incline, and from the surface is let down by a surface-incline to the railroad-switch. The two inclines are coupled together, and enough power is obtained from the surface-incline to work the mine-incline automatically. The mine-incline is 360 ft. long, and has a fall in this distance of 114 ft. The surface-incline is 1070 ft. long, with a total fall of 184 ft. The cost of hoisting the ore to the surface and lowering it again to the railroad is 10 cts. Mexican money per ton. On the underground incline a 2 by $\frac{3}{8}$ in. flat rope, and on the surface-incline a $\frac{5}{8}$ in. round steel rope is used. The ore handled by this method is of very low grade, but the mining expenses are kept at a low figure; the economy effected by the double incline is the only condition which has made it possible to operate the ore-deposit. During 1900 this incline handled 15,000 tons of ore.

Mine-Fires.—On account of the very large quantity of timber in the mines (nearly 4,000,000 ft. being used annually at prices varying between $25 and $30 U. S. currency per 1000 ft.), every precaution is taken to prevent fire. The use of steel miners' candlesticks is enforced, and fire-bosses are employed who have no other duty but to look out for signs of fire. In spite of these precautions, serious fires have occurred. One in the Veta Rica mine, in April, 1899, started in a lime-ore body adjoining the breccia-contact, which was filled with square sets. The fire rendered the mine inaccessible for several months; large caves of the overlying contact material took place, and serious loss was incurred.

Timbering.—Originally, Texas and Louisiana long-leaf yellow pine was the only timber used, on account of its great strength and fiber; but it has become fully recognized by experience that square-sets, as such, are of but little use where really heavy pressure has to be resisted, except when carefully and

promptly filled with waste rock. A much poorer grade of native lumber is now used, purchased from Durango at a cheaper rate than that paid for U. S. lumber, and filled as soon as conveniently possible after setting up. It is a question whether additional profit could not be made by using larger sets, since, on account of the low price of unskilled labor ($1.00 Mex. money or 50 cts. U. S. currency per day), the rock-filling can be done extremely well and cheaply. The cost of timber in the Sierra Mojada is approximately 50 cts. U. S. currency per ton of ore mined.

Water-Supply.—Among the interesting features of the camp are the large earthern storage-reservoirs for water, which have been built at various points by the mine-owners or operators. A small settlement of miners is usually found near each tank. At times these reservoirs become quite dry; and although the wells do not fail, they are so deep, and the supply is so limited, that it is more economical to bring water in by the railroad, from points along the Mexican Central railroad. Nearly every year a considerable quantity of water is shipped into the camp at a cost of from $2 to $4 Mex. money per 1000 gallons.

Labor.—Labor for the mines is fairly abundant. The Sierra Mojada miner earns usually $1.50 Mex. or $0.75 U. S. currency per day. He is industrious and intelligent, and will mine and timber in the heaviest ground with skill and confidence. The loss of life in the Sierra Mojada mines is very small, presenting in this respect a marked contrast to several other camps in Mexico. This is perhaps due, to a considerable extent, to the fact that many of the foremen and superintendents are Americans or Europeans, and, by reason of their position as aliens, are compelled to take every precaution against accidents for which they might be blamed.

Climate.—The climate of the camp cannot be surpassed. The almost entire absence of clouds and rain throughout the year; the clearness and purity of the air; the absence of cold winters and hot summers—all combine to make the place attractive in spite of its desert surroundings.

The Coal-Fields of Las Esperanzas, Coahuila, Mexico.

BY EDWIN LUDLOW, LAS ESPERANZAS, COAHUILA, MEX.

(Mexican Meeting, November, 1901.)

THE BASIN AT LAS ESPERANZAS.

FOR many years, coal has been known to exist in the valley of the Sabinas river, in the State of Coahuila, and for about 15 years it has been worked by the Mexican International Railway Co., which opened mines for its own fuel-supply when the railway was built, and has been mining continuously ever since.

The coal-basin worked by this company lies along the Sabinas river, principally on the SW. side. It covers a wide area and has been carefully prospected, but only in a few parts have the beds been found sufficiently thick and regular for economical operation.

This Sabinas basin was considered the only one in this field, until, in the Spring of 1899, the Las Esperanzas basin was found by Messrs. J. L. Elliot and E. D. Peters, who were in Mexico looking after some copper-properties. After a further examination by Mr. James T. Gardiner, of New York, the Mexican Coal & Coke Co. was organized in June, and active work was begun on Nov. 5, 1899.

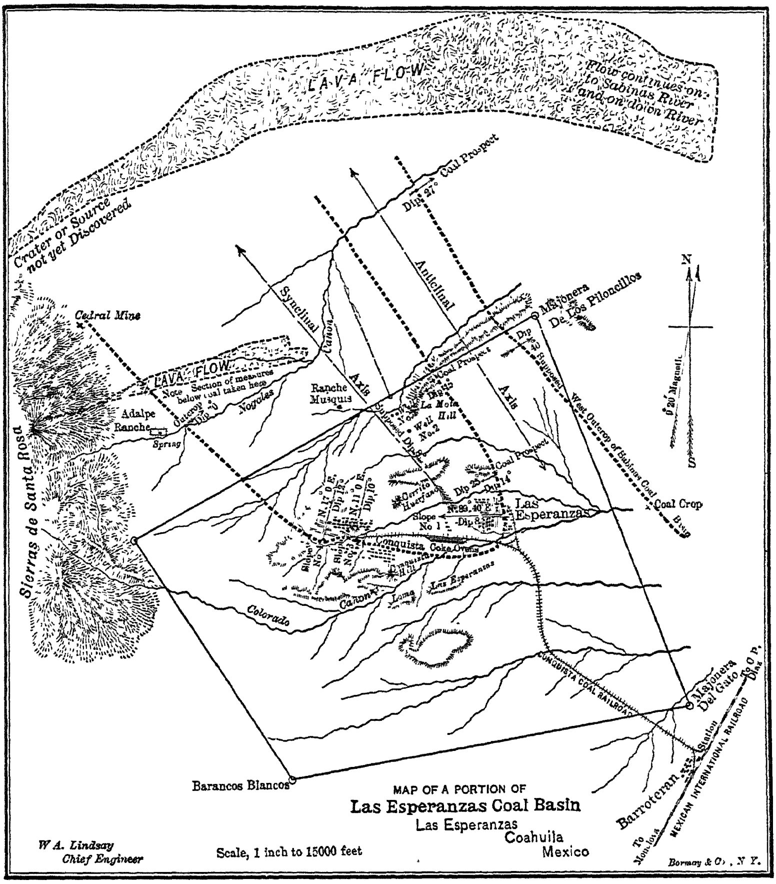
The coal-field of Las Esperanzas, situated in the State of Coahuila, about 85 miles SW. of Eagle Pass, Texas, adjoins and runs parallel with the Sabinas basin—an anticlinal separating the two outcrops by about 2 miles. Fig. 1 is a sketch-map of a part of the basin.

The coal-formation is in the Upper Cretaceous, and corresponds with the Laramie measures of the United States. The following geological section, taken in Nogales cañon, shows the measures between the massive limestones forming the Sierra de la Santa Rosa and the outcrop of the coal:

Section.	Feet.
Limestone,	Unknown.
Blue shale,	110
Shale and sandstone,	50
Bed of fossiliferous shale,	50

Section.	Feet.
Sandstone containing a large proportion of lime, . .	20
Sandstone strong in lime, with shale slips, . . .	8
Blue shale, ...	730
Soft sandstone, well bedded, with gray shale slips, .	120
Coal, ...	8
Sandstone and gray shale, in beds approximately parallel with synclinal axis, ...	4000

FIG. 1.



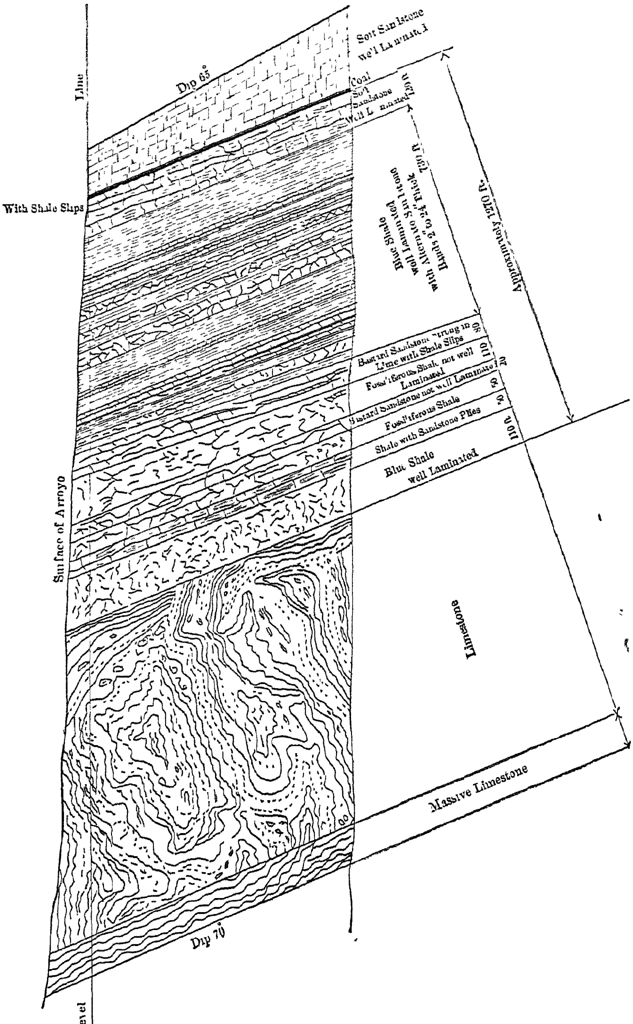
This section is graphically shown in Fig. 2.

The characteristic feature of the formation is the 1150 ft. of shale underlying the heavy sandstones. As the country is heavily covered with a gravel-wash, as thick as 100 ft. in places, and covering any exposures of rock, the shale served as a guide in the early diamond-drill work, always indicating when the hole was outside the outcrop by a characteristic wash

of what the drillers called "blue mud." The shale overlying the coal was more gray in color and could be easily distinguished.

This coal-basin runs from Las Esperanzas Hill, which marks

FIG. 2.



Section of the West Crop of Las Esperanzas Basin
in the Nogales Canon
Showing approximate depth of Coal Measures below the Barroteran Seam and their relative position and thickness.
Scale 1″=600 ft.

its SE. limit, in a N. 45° W. course, parallel with the Sierra de la Santa Rosa, for about 30 miles.

The dip of the coal at the Las Esperanzas end, where it forms its southern horse-shoe, is from 6° to 12°; but as the

axis of the basin dips 7° NW., and as the sides of the basin narrow instead of widen, the inclination of the coal becomes steeper as it goes N., so that, at 4 miles from its SE. end, it forms a V-shaped trough, with a SW. dip of 55°, and, on the other side, a NE. dip of 70° to 75°. The heavy dips continue until the horse-shoe is formed at the NW. end, where the inclination is again reduced to 6°; but diamond-drill explorations at that end of the basin showed less than 3 ft. of coal, and no development-work has been done there. The area of the basin at the SE. end, where the vein is of good thickness, with a dip not too steep for economical operation, is about 6000 acres. As shown on the sketch-map, Fig. 1, it is entirely enclosed within the property lines of the Mexican Coal and Coke Company.

Among the interesting features of the geology of this field are the lava-flows that came from craters in the Santa Rosa mountains, behind the outcrop, and covered the coal-measures in a sheet from 4 to 10 ft. thick, after they had been tilted into their present position. The first flow comes from between Nogales and Cedral cañons and reaches across the synclinal axis of the Las Esperanzas basin. The second and heaviest flow lies between Cedral and the town of Muzquiz, and not only crosses the Las Esperanzas basin, but also continues 15 miles towards the Sabinas river, and then, reaching the W. bank, goes on down the river for 30 miles to the Hondo mines of the International Railway Co. This lava-flow is only cut, within this distance, by two water-ways; and with these exceptions, it forms a prominent ridge, from 0.5 to 2 miles wide, standing from 100 to 150 feet above the surrounding country. The sides are always steep and show clearly the lava, capping the sandstones and shales of the coal-formation, with no apparent effect on their stratification.

The Beginning of Operations.

The writer arrived on the property on the night of November 5, 1899, and the view that met him next morning was not encouraging. He saw a cactus and mesquite desert with no trees, no houses (except a few "jackals"), and no water; but he was told that a small spring, 2 miles away, would furnish enough for drinking. The work already done consisted of prospect-holes about half a mile apart along the outcrop; and, as few

of these had gone through the surface-coal, the outlook, from a mining point of view, was not flattering.

The instructions from the New York office were to open mines and obtain a production of 5000 tons per day as soon as possible. That is what we have all been trying to do ever since; but although we have the plant to handle that amount, and sufficient coal in sight, it has so far been impossible to get enough miners to dig so large a quantity of coal per day. We have tried importations of American, negro, Japanese, Chinese and Italian miners; but not many of them would stay—the Americans preferring to work in the coal-fields of the United States, while most of the others were unaccustomed to any kind of mining, and only a few of the best had the requisite perseverance to stick by us, and learn how to mine coal.

Our Mexican labor we have had to teach and train. Many of our workmen of this class, coming from farms and cattle ranches, knew nothing about mining, and few of them appreciated the necessity of continuous labor; while many of those who came from the metal mines were more difficult to teach than green laborers, since their previous ideas of mining have to be eliminated before they can be taught to work for the large output necessary to a successful colliery operation. From some of the low-grade mining camps, like Sierra Mojada, however, we have obtained men who became, in a few weeks, good average coal-diggers, and some Mexicans have learned to be really expert, and would be so considered in any field. These cases are, however, exceptional.

An idea of the Mexican laborer's manner of working can be formed from the fact that, when we first put in tipple-scales, and paid the men by the ton for mining, they would invariably follow the car they had loaded out of the pit and find out how much it weighed, before loading another.

A study of the different results in the same mine, from the various classes of miners, gives the following averages in number of tons per day, loaded in pit-cars: Americans (good miners), 10; negroes (good miners), 8; Italians (fair miners), 6; Japanese (fair miners), 5; Mexicans (green),* 2; and Chinese, 4 tons per day.

* No average can be given for any Mexican miners except the inexperienced ones, since the expert Mexican miners all become contractors, employing from six to twenty laborers, and directing and inspecting, rather than personally laboring.

The boys are our strong hope. They work better and more steadily than the men; and, growing up to a daily routine of occupation, they will make better workmen than their fathers, who come to the mines from the intermittent working life of the farm or ranch. There has been also a marked improvement in some of the men. Many who came here when work was first started, wearing blankets and sandals, now dress in good style, wearing shoes, often of American make; and the sale of American furniture and cooking-stoves is constantly increasing.

As hoisting-engineers and helpers in the machine-shop, we have found the natives good, where the work is laid out for them; but they lack initiative in taking hold in case of any break-down; and it is necessary to keep American foremen in nearly every department. As mechanics, carpenters and blacksmiths, we are always able to get Mexicans competent to do any work laid out for them.

In planning the mining work we had "a clean slate." The coal-basin was defined by the prospect-shafts; and it only remained to locate the openings at the most advantageous places for economical operation, and where the tipples could be located so as to bring the railroad to them without any bad grades or heavy work of construction.

Slope No. 1 was located at what is now called the town of Las Esperanzas (see Fig. 6), and was sunk at right angles to the strike on a due W. course. Slopes Nos. 3 and 4 were located on the other side of the basin about 3 miles W., and run due N. Room was left at the end of the basin for Slope No. 2, to be put in at some future day.

The problem was to devise the best kind of tipple with the smallest practicable use of heavy timber (on account of its expense); and also to arrange for a thorough cleaning of the coal, since the vein contained bands of slate which could not be removed underground, especially with labor that did not know coal from slate. We therefore adopted the tipple shown in the plates, in which the cars are hoisted up the slope and run by gravity from the mouth of the slope to the foot of an endless chain which catches the front axle automatically and carries the car to the top of an incline, where it detaches itself and runs over a mine track-scale, with a large weighing-dial

so set as to come to zero with the empty car. The hand of the dial swings around as the loaded car passes over, showing the weighman the exact weight of coal contained in the car, without the necessity of stopping the car on the scales. It then runs over a Phillips automatic cross-over tipple, dumping the coal on the bars, and, being bumped off by the next car, runs down an incline to a back-switch, and from there, by gravity, back to the mouth of the slope, where it is coupled up, in trips of from 10 to 12 cars, to go down into the mine. The hooks on the car-hoist are so placed as to allow 6 cars per minute to be hoisted and dumped. This gives a capacity of from 8 to 10 tons per minute, which will take care of the coal as fast as we shall be able to mine it, when fully opened.

The coal, when dumped, goes over 1-in. bars and passes onto a picking-belt of iron slats, 3 ft. wide and 30 ft. long, arranged so that boys can stand on either side and pick out the slate from the coal as it passes by them. The coal passing through the 1-in. bars falls on a shaking-screen with $\frac{3}{8}$- by $\frac{3}{4}$-in. perforations; and the dust which passes through is sent to the coke-ovens, while the pea-coal passing over is either shipped for steam-coal or carried on another belt, to go in the same car as the lump, making "mine-run" for the railroad-trade.

The mines are ventilated at present by temporary fans, 12 ft. in diameter; but two Cappell fans, each of the capacity of 150,000 cub. ft. of air per minute, have been ordered, and should be in operation by the first of next year.

As part of the general equipment, we have had to put in a machine-shop, with lathe, drill-press, shaper, bolt- and pipe-cutters, and a bolt-header. Also, a hospital, with two rooms for patients, and a drug-store, with quarters for the doctors.

Since it was found to be very expensive to have ice brought to us, a 5-ton ice-plant was installed in connection with the butcher-shop; and the cold-storage furnishes beef and mutton much better than can be usually obtained in Mexico.

School-houses for both Americans and Mexicans, a court-house and jail, post-office and telegraph-office, all became necessary as the plant expanded.

The property, being what is known in Mexico as a *Hacienda*, has a self-contained government of its own.

The Canteen.

One of the early troubles, which was extremely annoying, was the drunkenness, due to the use of the native liquor *mescal*, by the American miners brought here. Not being accustomed to this drink, and not having been able previously to get so much effect for the same money, they would absorb it too eagerly, and the result was extremely bad, since few Americans who once get the *mescal* habit recover from it, if they remain in the country. The effect of this liquor seems to be similar to that of absinthe, affecting its victims not only physically, but mentally. To combat this evil, we not only forbade the sale of *mescal* on the property, and enforced this rule as rigidly as possible, but also opened a "canteen," which was entirely in our control, and in which we allowed nothing to be sold but beer and light wines. The effect has been very good. While there is some drunkenness, it is not of the serious kind we have had before; and the canteen, with its billiard- and pool-tables, forms a place where the men can spend their spare time.

The Water-Supply.

One of the most pressing problems in a camp of this kind, in a country where there is seldom even dew, was to get a sufficient water-supply. The mines, as they were opened, encountered a little water; but the quantity did not increase and was not enough for boiler-supply, while the quality was not suitable for drinking.

We searched the nearest cañons in the Sierra; but, while we found more or less running water in each one, they would all require expensive pipe-lines from 8 to 12 miles long, and the amount in no one case was large. We then started to develop a small spring that was already on the property, and remembering the Texas adage, "Climb for water and dig for wood," we dug a series of wells up the hill from the spring, and met with great success. The last well, sunk directly on top of the hill, is the best of all, and at a depth of only 45 feet has a capacity of 200,000 gallons per day. The other two wells are on independent streams, although only 150 feet away, and have a capacity of 100,000 gallons each.

We now have an adequate supply for all purposes, except irrigation; and as irrigation would be for adornment, rather than business, we will have to postpone it for a while.

The peculiarity of this water-formation is shown by our having, at the foot of this same ridge, a diamond drill-hole, 700 ft. deep, that showed no water at all.

The water, though otherwise pure, contains a good deal of lime, making it hard on boilers; but it is an excellent drinking-water, and analysis shows it to be absolutely wholesome.

We have built a stone reservoir on top of the hill, into which the pumps at the various wells throw their water, and from which it flows by gravity, through a 6-in. pipe-line, to the coke-plant, and through a 3-in. line to Las Esperanzas, the difference in elevation being about 90 ft. The No. 3, or Conquista mine, being on the same level as the reservoir, we have to pump from the coke-plant what is needed there.

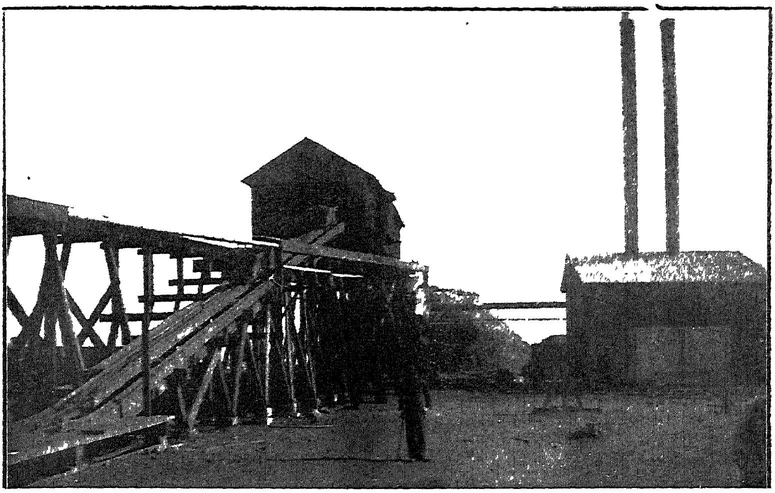
While the distance from the wells to the mines is two miles, we feel that we are extremely fortunate to find such a supply of pure water on the property, in a country where water is so scarce as it is in this part of Mexieo.

The Mining Development.

Three slopes were located, Nos.1, 3 and 4. Tipples were built at Nos. 1 and 3; but No. 4 being at the head of a ravine, it was not practicable to operate a railroad economically to that point, and arrangements had to be made to bring the coal to the tipple at slope No. 3, 3000 ft. further east. This was done by driving a drift on the vein from the surface-level, near the mouth of slope No. 3, into the hill, intersecting slope No. 4 at a point 400 ft. from the surface; so that all the coal from that slope is back-switched and brought by mules to the mouth, a distance of 1500 ft. From there, as the grade is about 2 per cent. in favor of the loads, a hoisting-engine is used, the loads pulling the rope to the tipple, where it is attached to a corresponding number of empty cars, which are hauled to the mouth of the drift. The road from there to the slope is slightly in favor of the loads; and two mules, hitched tandem, haul twenty cars each way, the loads averaging a little over one ton per car.

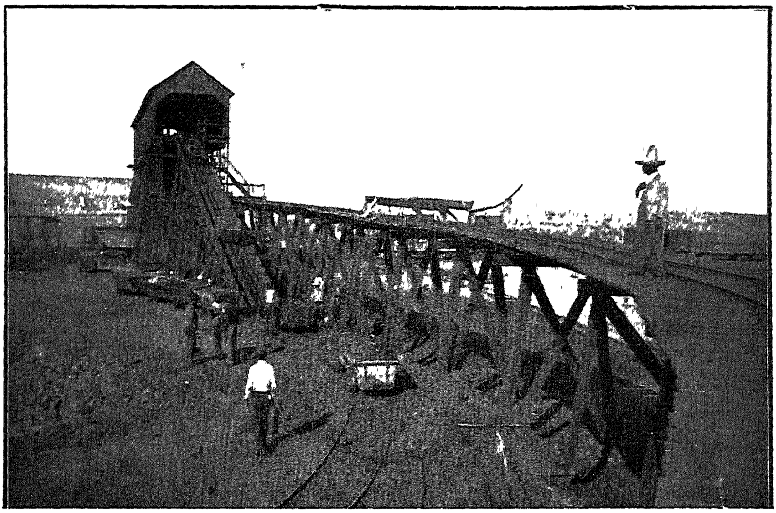
The slopes are all single-track, with entries turning to the right and left, 300 ft. apart. Nos. 3 and 4 are each now turning their fourth lifts; and the output from these two slopes is now 750 metric tons per day, and should steadily increase as more

FIG. 3.



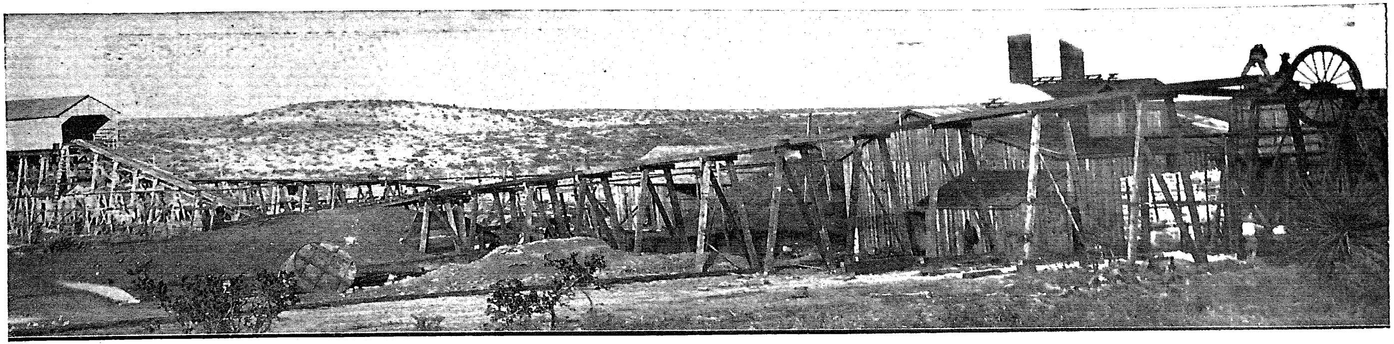
No. 1 Tipple with Cars on the Incline.

FIG. 4.



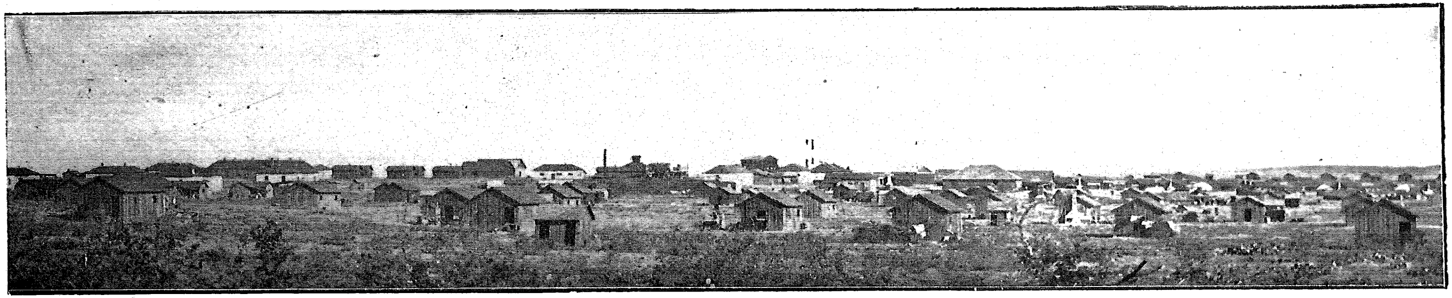
No. 3 Tipple with Cars on the Incline.

Fig. 5.



A General View of No. 3 Tipple.

Fig. 6.



View of Las Esperanzas, looking East.

ground is opened and men can be obtained to fill the working-places.

Slope No. 1, at Las Esperanzas, is down six lifts of 300 ft. each, and is producing about 550 metric tons per day. We have sufficient opening at this mine for 200 more men; and if they could be obtained, they would bring the output up to about 1000 tons per day. Fig. 3 shows the tipple at No. 1.

Both No. 1 and No. 3 are equipped with 30 by 42 in. first-motion engines, made by the Litchfield Car and Machine Co., of Litchfield, Ill., and have wood-lagged cylindrical drums, 8 ft. in diameter and 8 ft. long. These will have a capacity, when the mines are fully opened, to hoist 40 tons at one time, a distance of 4000 ft. If sufficient miners can be obtained, we should have no trouble in shipping from 5000 to 6000 tons per day from the two tipples. Figs. 4 and 5 are views of No. 3.

We have also at each of these slopes an Ingersoll-Sargeant 20 by 22 in. air-compressor, furnishing air for the pumps and auxiliary hoist, used in sinking the slopes below the last lift, and also for running such air-machines as we can find runners to operate. We have nine of the air-machines of the punching type made by Ingersoll-Sargeant and Sullivan Co., but are seldom able to run more than four or five of them, as Mexicans do not take to that kind of work, and it is difficult to obtain Americans.

The Coal-Formation.

The coal in this basin is a soft bituminous coking coal. The following analysis was made at the No. 3 smelter of the Guggenheims, at Monterey, from our commercial shipments to them of lump-coal:

	Per cent.
Moisture,	2.0
Volatile matter,	20.5
Fixed carbon,	67.7
Ash,	9.8

The average section of the vein at Slopes 3 and 4, where it runs very regular, is, from the top down:

	Ft	In.
Coal,		10
Bone,		2
Coal,	2	6
Fire-clay,	1	0
Coal,	3	6
Total thickness,	8	0

Total coal, 6 ft. 10 in. Impurities, 14 in.

The great regularity of the vein is shown in the middle parting of fire-clay, which does not vary over 1 in. in thickness in the total workings of the mines, and shows as a white streak throughout the whole development. The roof in this mine is, however, quite bad. Above the coal there is a rotten slate about 18 in. thick, and above that 10 in. more of coal. In some places the slate hardens up enough to make a fair roof, and in others it is so soft that both entries and rooms have to be double-timbered. This adds greatly to the expense of mining, as most of the timber has to be brought from the pine-belt in eastern Texas.

At Slope No. 1 the conditions are somewhat different. Here we have a strong sandstone roof, which only requires a few props in the rooms. The middle parting is not as regular, and on the south side swells up so thick as to prevent us from working the coal economically in the lower bench, and leaves us only the 4.5 to 5.5 ft. of upper seam to take out; but on the north side, after passing an upthrow of a few feet, we find the vein regular, and with the following section in feet and tenths:

	Feet.
Coal,	0.9
Bone,	0.2
Coal,	1.4
Sulphur band,	0.1
Coal,	0.6
Bone,	0.3
Coal,	1.0
Fire-clay parting,	0.8
Coal,	0.1
Bone,	0.1
Coal,	3.4
Total,	8.9

Total coal, 7.4 ft. Impurities, 1.5 ft.

Sections in some of the lower entries show a total thickness of 9.5 ft., the increase being nearly all coal. The outcrop of the vein shows a gradual increase in thickness as it goes N. W. from south of Slope No. 1. A hole on Telegraph Hill, one mile N. W., shows a total thickness of 12 ft.; and near the Mota Hill, two miles from the mouth of Slope No. 1, the vein shows a total thickness of 24 ft., the proportion of coal and impurities remaining about the same. The pitch at this point, however, is 45°, and the coal at the outcrop-shaft is quite soft.

THE COKING-PLANT.

The consumption of coke in the smelters of northern Mexico amounts to about 20,000 tons per month, and is rapidly increasing, not only by reason of additional demand from the new smelters that are being constructed in different mining fields to meet the constantly increasing output of metalliferous ore, but also from the iron-works being constructed at Monterey and Durango. The company therefore decided that coking would be a very necessary adjunct of our business; and we have constructed the first block of 224 ovens, and have 100 of them fired up. The remainder will be in operation about the first of next year.

The ovens are of the bee-hive type, 12 ft. in diameter, and vary only in two particulars from the Connellsville standard. These changes have been made to meet the requirements of our coal, which carries only about 20 per cent. of volatile matter, necessitating that every means be used to ignite the charge quickly.

The first change was, to build an air-duct entirely around the ovens, opening at each end through the stone walls, and connecting with the oven by small holes, a half-inch in diameter, and a foot apart. This gives a uniform supply of air to the charge, coming in over all parts of it, whereby we obtain more uniform results than by having the only opening in the top of the door. We leave this air-duct open until the charge begins to burn freely and then gradually close it to avoid over-burning the top. Care must also be taken in studying the force and direction of the wind, so as to avoid furnishing an over-supply of air.

The second change was, to build connecting-flues 8 in. square between every two ovens and to have a damper, with a handle running above the top of the ovens.

When an oven is freshly charged, the ovens on either side have usually been burning one or two days, and are in full heat. By opening the dampers and partially closing the top of the connecting ovens, the gases are forced into the freshly-charged oven, and cause it to ignite about an hour sooner than when left to start itself from its own heat.

We were fortunate in finding a quarry of good rock, running from 10 in. to 14 in. thick, only a half mile from the ovens.

The fire-brick had to be all purchased in the United States, most of it coming from St. Louis, Mo.

The Washer.

In order to make a coke acceptable to the smelting-trade, it was necessary to wash our slack before coking. With the unwashed slack we made a coke averaging 15 per cent. of ash; but the lead-smelters insist upon a cleaner coke than this. The problem of the washer was to remove the bony coal, which caused most of the high ash, and yet had a specific gravity very nearly the same as the coal. The various types of washers in use in the U. S. coke-fields were studied especially with regard to this point; and the Campbell washer was decided upon as the simplest and most economical and still meeting the necessity of delicate separation. It is a bumping-table with a curved bed and riffles, to prevent too rapid a flow. The coal and water are introduced about the middle, where the table is deepest, and the bumping motion causes the heavier particles to first settle and then travel up an incline, and off at one end of the table, while the coal and water pass off at the other end. The table is easily adjusted with a lever so as to make it steeper or flatter, as may be required to meet any changes in the character of the material; and it can be arranged so as to prevent any coal passing off the slate-end, or any impurities going with the coal.

This washer has been running only a short time; and we have not been able to have an analysis made of the coal and slate, as will be done daily, when we have the work more thoroughly systematized.

The Washer-Building.

In order to provide for future requirements, the washer-plant was designed to handle 1200 tons of slack per day.

The fine slack-coal at the mines is loaded in side-dump railroad cars, which discharge freely, and is then pushed up on a trestle at the washer. The coal falls in a hopper, 100 ft. long, running under the trestle, from which it is fed into a conveyor that carries it to the end of the washer-building, where a screen-conveyor gives a regular discharge into an elevator, which lifts it to the top of the building, and discharges into a conveyor running its length and emptying into a long hopper, from which

the coal feeds directly onto the washer-tables. We now have twelve of these tables; but room has been left for double that number.

After passing over the tables, the coal falls into another conveyor-line, which takes it back to the end of the building, where another elevator lifts it to the top of the 2000-ton storage-bin. It is distributed in this building by a conveyor which discharges through slide-doors in the bottom of the conveyor-trough into whichever compartment of the building it is desired to fill. There are at present three compartments, each one capable of holding a day's run, so that the water is allowed to drain off for 48 hours before the coal is used.

Under the storage-bin another conveyor brings the coal to the end of the building, where it empties into a conveyor, running on an incline of 30°, which takes it to the top of the larry-bin. The slate coming off the other end of the washing-table is carried by the idle chain of the coal-conveyor to the opposite end of the building, where an elevator loads it onto railroad-cars, and it is carried to the waste-pile. A locomotive handles the larries running on a standard-gauge track, built on top of the ovens.

The conveyors are all of the double-strand Monobar type, and are extremely satisfactory for this purpose. A 200-H.P. engine furnishes the power for the entire plant.

The water, as it drains from the storage-bin, is caught in masonry-tanks, and pumped into settling-tanks, to be used over again as soon as clean.

The analysis of the coke, as made by the Guggenheim Smelter No. 3, at Monterey, is as follows: Water, 0.5; volatile matter, 0.9; fixed carbon, 83.9; ash, 14.7; sulphur, 0.96 per cent.

The analysis of the ash is: Fe, 8.4; Al_2O_3, 17.3; CaO, 4.0; SiO_2, 59.6; S, 1.6 per cent.

The same parties analyzed also a sample of the first coke made from our washed slack, with the following result: Water, 0; volatile matter, 1.4; fixed carbon, 87.3; ash, 11.3 per cent.

We expect to produce still better results, when the washer has been run longer and everything is moving smoothly, and more especially when the Mexican boys have learned how to keep the feed of water and coal regulated. We should bring

the ash down to 8 or 10 per cent., and, with careful burning, be able to make a 72-hour coke which will satisfy the most exacting demands of the lead-smelters.

These mines should be of great assistance to all steam- or coke-users in the Republic, especially in the northern part, as they will furnish a fuel not only cheaper than the imported article, but also having the very great advantage of being supplied in regular quantities, as may be needed, thus enabling consumers to avoid the carrying of large stocks, which is necessary when, as now, importations by vessels are depended upon.

The present output of about 1200 tons per day is sold to railroads and steam-users throughout the Republic, principally, however, in the northern part. In the southern end we meet a strong competition from West Virginia coal, coming by water to Tampico and Vera Cruz. The development that has been made on this property in the last two years should convince anyone examining the plant that the earlier statements that "there was no coal in Mexico" are not borne out; that there is enough good coal in sight to meet all reasonable demands of steam-users; and that fuel for that purpose, and at a reasonable price, is no longer one of the difficult problems for a projected industrial enterprise to solve.

The Iron Mountain, and the Plant of the Mexican National Iron and Steel Company, Durango, Mexico.

BY T. F. WITHERBEE, DURANGO, MEX.

(Mexican Meeting, November, 1901.)

The Iron Mountain, situated three-quarters of a mile NE. of the limits of the City of Durango, rises abruptly from a level plain, and trends N. 83° E. Fig. 1 gives a view of the mountain, with the company's iron-works. There are indications that the vein or deposit of iron-ore extends also about two leagues across the *Murca* ranch, in the same general direction. The Iron Mountain proper is divided into two great lenses by a horse of *cantera* or eruptive rock, some hundreds of feet in width.

The mass of solid ore is about 1⅓ mile long by ⅓ of a mile wide, and from 200 to 400 ft. high, the latter being the elevation of the cross. A conservative estimate of the amount of ore in sight, above the level of the plain, after making due allowance for the horse, is 360,000,000 tons, as shown by re-survey and measurements made during the last six months.

The ore is specular hematite, martite, or magnetite, according to locality. It is generally hard, or massive, although at the western end, at the cave, where the only mining has been done, it comes out as fine powder, or the lumps disintegrate into powder upon exposure. This powdery ore is used as "fix" in the puddling-furnaces, because of its low silica.

Physically the ore is one of the hardest and strongest rocks. It is very severe on the wearing-parts of crushers, and will cut into the face of a steel hammer, regardless of its temper.

A curious fact noted by all who have examined the deposit is that, while the massive ore and the crystals yet retain their sharp and perfect edges, lumps of iron-ore in the *talus* or *débris* which surrounds the solid formation on all sides are rounded or nodular—the reason of which is not clear. These nodules are imbedded in a stiff clayey matrix which holds them quite firmly, so that mining with pick and shovel is sometimes profitably aided by explosives.

Practically all the solid ore is covered by 121 *pertenencias;* 118 owned by the Mexican National Iron and Steel Company, and 3 by the Flores estate. Iron-denouncements have been made outside of these limits; but they are of little importance, as the layer containing the rounded lumps is only from 2 to 4 ft. thick, and is rapidly exhausted.

As shown by the analyses given in the appendix, the ore is very high in metallic iron, while the phosphorus runs from as low as 0.035 to more than 1 per cent.

In some places the massive ore is decidedly columnar, like basalt; and there is some evidence of its having been in a state of fusion—for instance, outlying patches of ore, from 2 to 3 ft. in thickness, evidently broken up in place, and assuming a rounded form; also, large lumps of what appears to be solid iron-ore, which, upon breaking, prove to be only pieces of *cantera*, covered with a superficial coating of iron oxide, often highly crystalline, and only from 0.25 to 0.5 in. thick, as though the rock had been immersed in molten iron oxide.

Crystals are most numerous, and more perfect, next to the eruptive rock.

Considerable prospecting has been done on the mountain for gold and silver, and traces of the latter are often found. At one place on the *Murca* ranch, in a ledge of solid iron-ore, as much as 9 oz. of silver and 0.5 oz. of gold per ton has been found. For more than 50 years this ore has been used in a cold-blast charcoal-furnace some 7 miles away, owned by the Flores estate, and since 1888 it has been used in the furnace of the Mexican National Iron and Steel Co. Its use as a flux by the lead smelters at Monterey, Aguascalientes, Velardeña, Mapimi, and other localities within reach, dates from 1893, and amounts to over 400,000 tons. Iron made from the ore with charcoal has exceptionally good chilling-qualities, which render it specially desirable for the wearing-parts of rolls, crushers, grinding-pans, quartz-mills, etc. Even the "straight" white iron is very strong, and, in the foundry, retains its fluidity like gray iron. When coke is used in the blast-furnace, a fine quality of foundry-iron, of great strength, is the result. Above 2.75 per cent. silicon the iron becomes closer in grain as the silicon increases; but its softness and fluidity are retained.

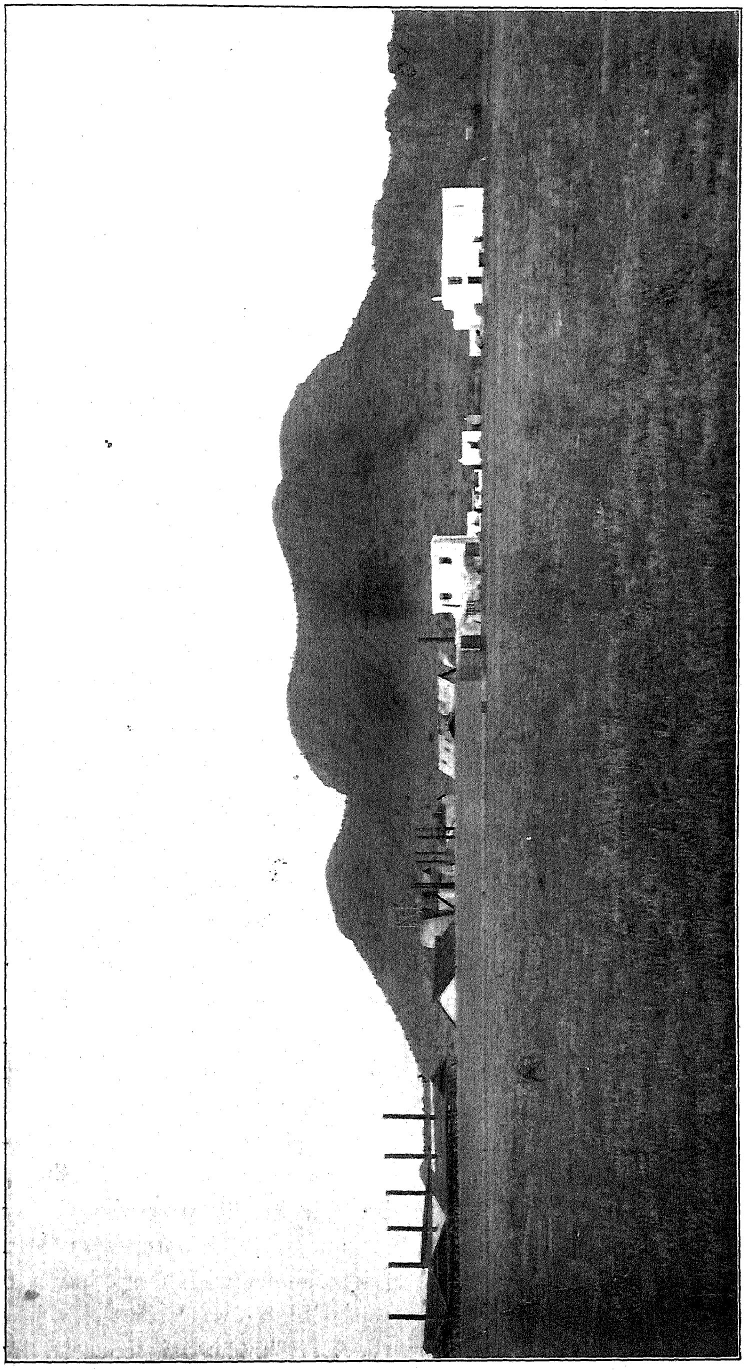
The following system of grading pig-iron is used, and has proved satisfactory when attention is paid to it, and the user knows what he needs:

Grade.	Silicon, per cent.
Mill-iron,	Up to 1.25
No. 3 Foundry,	1.26 " 1.50
No. 2 "	1.51 " 1.75
No. 1 "	1.76 " 2.00
No. 1x "	2.01 " 2.25
No. 3 High silicon,	2.26 " 2.50
No. 2 " "	2.51 " 2.75
No. 1 " "	2.76 " 3.00
No. 1x " "	3.01 and over.

Sulphur runs below 0.05 per cent., and phosphorus from 0.40 to 0.65 per cent.

It will be noticed that the foundry and high-silicon brands differ by exactly 1 per cent. of silicon for corresponding grades.*

* In order to show the fallacy of grading pig-iron by grain, two samples were shown at the meeting, one containing 4.32, and the other 0.75 per cent. of silicon. The average foundryman might not take either to be a "scrap-carrier," or, if he did, would surely choose the wrong one. Other samples of iron-ore, pig- and bar-iron—the latter bent cold—were exhibited to show the excellent quality of the products of this plant.



The Iron Mountain, Durango, Mexico, Showing Works of the Mexican National Iron and Steel Co.

The blast-furnace is at the base of the western end of the mountain, and is underlain by the stratum of nodular, or loose ore, covered to a considerable depth by the clayey matrix.

The ore is hauled up an inclined plane, 180 ft. long, to a 10 by 16 Blake crusher, from which it is automatically discharged into two 7 by 10 crushers; and thence, broken to about chestnut size, as a maximum, with considerable fine ore, it falls to the stock-house floor. It is charged into the furnace by the old way, in barrows.

The stack has the following dimensions:

Height,	65 ft.
Diameter of bosh,	9 "
" of crucible,	5 "
" at stock-line,	6 "
" of bell,	4 "
" of tuyeres,	4 in.
No. of tuyeres, 4.	

Blast is supplied by a vertical direct-acting Todd engine with steam-cylinder of 38 in. diameter and 48 in. stroke, and air-cylinder of 84 in. diameter and 48 in. stroke. Steam is supplied by 4 return tubular boilers 66 in. in diameter by 18 ft. long, and 1 125-H. P. Heine boiler. Usually, three tubulars supply sufficient steam for the blowing-engine, crusher-plant, machine-shop, blacksmith-shop, and electric-light plant. The blast is heated by one 40-pipe Cochrane stove, practically the same as the "Cooper." As about 5500 cub. ft. of air pass through said stove per minute, the temperature is very low, seldom reaching 400° F.

The fuel used is charcoal, or a mixture of charcoal and coke; the latter from Sabinas or Baroteran, in the State of Coahuila, Mexico. On charcoal alone, the blast-pressure is very high, from 6 to 12 lbs.; but a mixture of one-quarter of Baroteran coke reduces it to 5 lbs. or less. The use of coke affords also a ready and sure means of controlling the silicon in the pig-iron.

The present furnace-stack itself is hardly up to date, being built of cut stone, some 35 ft. in diameter at the bottom by 55 ft. high (topped out with 10 ft. of iron shell), with deep, low and narrow arches, rendering it impossible to work in them just when work has to be done there. The bosh is covered by

a wrought-iron jacket, supplied with vertical cooling-pipes, which, by the way, are of little use in preserving the bosh. The tuyere-section is protected by water-cooled cast-iron plates, and water-cooled square or rectangular tuyere-coolers. Iron coolers are used by preference, while the intermediate and blowing tuyeres are of bronze. The Lürmann closed cinder-front is used in two arches. The combination charcoal- and coke-furnace, which will soon replace the present one, will be from 65 to 75 ft. high, and capable of being lined to 16 ft. diameter of bosh. Much of the material for the new stack is now on hand. Two C. H. Foote fire-brick stoves will be erected, 65 ft. high by 18 ft. in diameter, with a combined heating surface of 52,000 sq. ft.

The natural fuel for this locality is charcoal, which can be laid down at the furnace for less cost per ton than coke in Chicago. Limestone, both *caliche* and crystalline, of good quality, is found anywhere from 25 miles out on the line of the Mexican International R. R.

The greater part of the product of the present furnace goes to the rolling-mill, about 250 ft. west of the furnace. This mill contains 5 double puddling-furnaces, a Siemens regenerative heating-furnace, and gas-producers; a combination 18-in. muck- and bar-train, a 10-in. finishing-train, with the necessary complement of shears, crusher, grinding-pan, squeezer and roll-lathe. The 10-in. train turns out rounds from $\frac{3}{8}$ to 2 in.; squares from $\frac{3}{8}$ to 2 in., and flats from $\frac{1}{4}$ by $\frac{3}{4}$ up to 4 by $1\frac{1}{4}$. The 18-in. bar-mill has a capacity for rounds up to 6 in., and for flats up to 8 in.

The foundry is at present only 80 by 65 ft. in size, but will soon include the space now occupied by the machine-shop, which will make it 190 by 65 ft. It has one 48- and one 24-in. cupola, and the weight of the castings made is only limited by the crane-capacity. The present machine-shop is 110 by 65 ft. in size; but a new one is to be built, measuring 250 by 65 ft., and supplied with regular and special tools for the manufacture of all kinds of mining- and milling-machinery. The present tool-equipment includes a planer 48 in. by 48 in. by 16 ft., and a lathe to turn pieces up to 10 ft. in diameter. The blacksmith-shop has 8 fires and 1 heating-furnace, with a steam-hammer capable of forging shafts up to 7 in. diameter. A 4000-lb. steam-hammer will be added to the new shop.

The manufacture of Hooper pneumatic concentrators is now under way, and special tools will be provided to turn them out rapidly and cheaply. A Hooper testing-plant is now in operation, in which ores are tested for concentration by that system.

An interesting feature connected with this plant is the fact that, excepting heads of departments, all the labor, skilled and unskilled, is Mexican throughout. Moulders, machinists and blacksmiths are satisfactory, as is also the blast-furnace labor, including night- and day-foremen. In the rolling-mill astonishingly good results have been obtained with such labor, after a very short time of training. The average experience of the puddlers, puddlers' helpers, roughers, rollers, heaters and gasmakers at the rolling-mill does not exceed one year. The number of puddling-furnaces will be doubled as soon as sufficient labor can be educated, making the puddling-department equal to the rolling-capacity.

APPENDIX.

Analyses of Iron-Ore of the Iron Mountain, Durango.

	1.	2.	3.	4.	5.	6.	7.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
SiO_2	5.58	6.12	10.80	5.04	3.74	3.18	7.02
TiO_2	....	....	....	....	....	....	....
Al_2O_3	1.93	1.73	0.65	0.69	0.93	0.18	2.06
CaO	2.80	3.80	1.25	0.20	0.50	0.80	1.15
MgO	0.36	0.34	0.41	0.09	0.17	0.23	0.22
SO_3	....	....	....	....	....	....	....
S	0.35	0.019	0.017	0.026	0.019	0.033	0.024
P_2O_5	....	....	....	....	....	....	....
P	0.785	0.369	0.316	0.210	0.309	0.199	0.275
Fe_2O_3	....	....	....	....	....	....	....
Fe	60.48	....	59.95	65.55	65.15	65.95	60.85
Mn	0.30	0.29	0.32	....	0.13	0.30	0.26
Loss on ign	1.06	0.80	0.16	0.44	0.84	0.80	2.08

The analyses recorded in this table have been copied from the Report of Robert W. Hunt, dated March 28, 1901, and represent different parts of the property, as follows: 1. Mass in place, on N. boundary; 2. The "cave"; 3. Drift on E. face of property; 4. Boulders in place on Ridgely peak; 5. The Cross (a monument erected on the summit farthest to the right in Fig. 1); 6. Western face of property; 7. Stock-pile at furnace.

Analysis of Sabinas Coke.

	Per cent.
Moisture,	0.11
Volatile combustible,	2.32
Fixed carbon,	79.00
Ash,	18.57
	100.00

Analysis of Ash from Sabinas Coke.

	Per cent. of Coke.	Per cent of Ash.
Silica,	9.98	53.52
Alumina,	5.33	28.61
Ferric oxide,	1.44	7.71
Metallic iron,	0.71	3.81
Lime,	0.72	3.89
Magnesia,	0.31	1.61
Sulphur,	0.15	.83
Phosphorus,	0.003	.0137
	18.643	99.9937

Analysis of Baroteran Coke, Unwashed.

(Iron Mountain Co.'s Analysis.)

	Per cent.
Moisture,	0.12
Volatile combustible,	0.22
Sulphur,	0.55
Fixed carbon,	82.36
Ash,	16.75

Physical Tests of Bar-Iron from Samples Taken at Random from Stock.

(R. W. Hunt's Report of March 28, 1901.)

Size.	0.5 in. round.	1 in. round.	0.5 in. sq.	1 by 0.25 in.	2 by 0.625 in.	3 by 0.75 in.
Tensile Strength per sq. in., lbs.	50,610	48,420	51,860	54,060	49,200	49,020
Per ct. of Elongation in 8 in.,	22.5	30	25	19.5	21.75	20.25
Per ct. of Reduction in area,	30.73	43.8	40.36	27.4	29.4	25.25

Character of fracture fibrous in all five cases.

The Geographic and Geologic Features, and their Relation to the Mineral Products, of Mexico.

BY ROBERT T. HILL, U. S. GEOLOGICAL SURVEY, WASHINGTON, D. C.

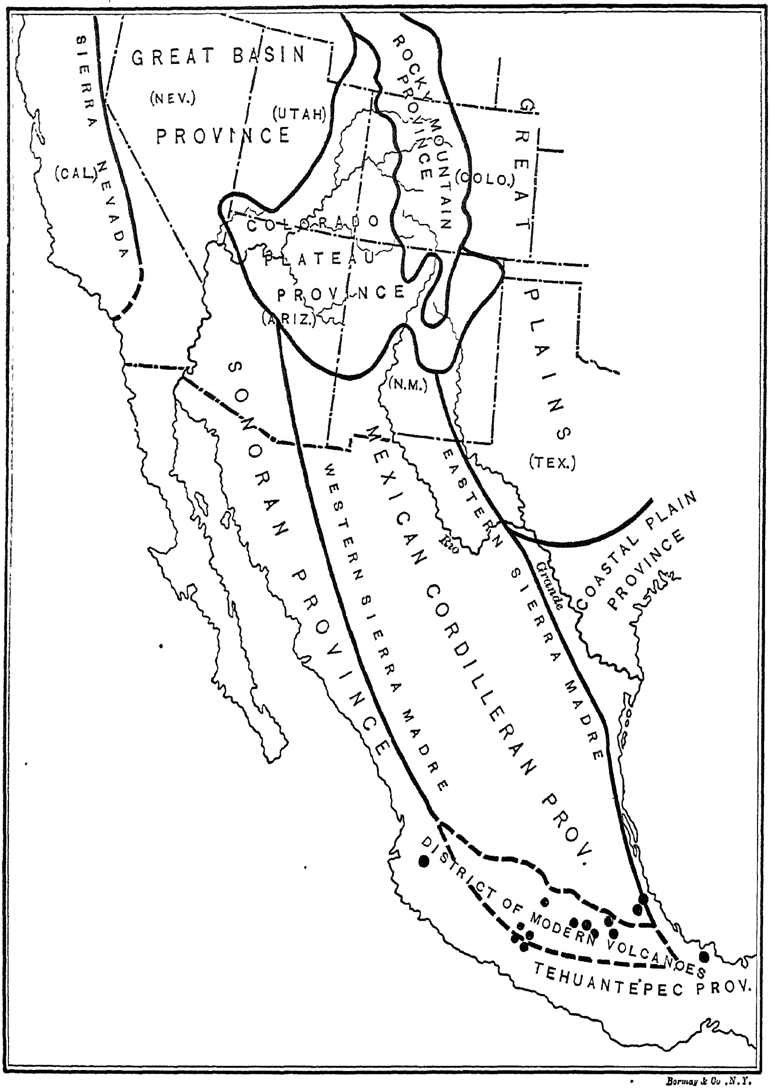
(Mexican Meeting, November, 1901.)

PHYSIOGRAPHICALLY, Mexico is divisible into four provinces, which are, in a manner, distinct economic areas. These may be denominated, (1) the Gulf coastal plain; (2) the Cordilleran plateau; (3) the Sonoran, and (4) the Tehuantepecan province. Fig. 1 shows the approximate boundaries of these provinces.

The first is the continuation of the coastal plain of Texas and the Gulf region in general, which, except for prospective oil and lignite, has little of interest for the mining engineer.

The Cordilleran Plateau province occupies two-thirds of the surface of the Republic, and is the chief seat of metallic min-

FIG. 1.



Physiographic Provinces of Mexico and the Adjacent United States.

ing. The Sonoran province is California-Nevadan in its relations, and, like the Cordilleran, is a large field for metals. The Tehuantepec province, at the south end of the Republic,

beyond the abrupt termination of the Cordilleras, is Central American in its aspects and relations, and will not be extensively discussed in this paper, which deals chiefly with the Cordilleran and Sonoran provinces, the chief sources of the metallic minerals.

I. The Coastal Plain Province.

The Coastal Plain province of Mexico is broken into one major and several minor divisions by the encroachment of the Cordilleran mountains upon the sea, between Tampico and Vera Cruz. The greater division of the coastal plain lies adjacent to the Rio Grande, and is the continuation of a similar feature in Texas. Small patches of the coastal plains are found farther southward toward Vera Cruz and Tobasco, and the peninsula of Yucatan is a wider expansion of it to the southward. The formations underlying the coastal plain are but little deformed, and are principally composed of the sands and clays of the Pleistocene, Tertiary and Upper Cretaceous formations.

The coastal plain of Mexico has never been studied systematically. Large deposits of maltha and asphaltum are known to occur along its western margin in Tampico. The oil-bearing formations of Texas extend into the State of Tamaulipas, with appearances of prospective value. Two flowing oil-wells are known in the State of Tobasco, and oil may occur in Vera Cruz. The only Mexican coal-field of present commercial value is the Eagle Pass, on the extreme western margin of the coastal plain, adjacent to the Mexican International Railway, near Sabinas and Baroteran. The coals are from strata of Upper Cretaceous age.

II. The Cordilleran Plateau Province of Mexico and its Accompanying Basin-Plains.

The Cordilleran Plateau province occupies the central mountainous area of the Republic. Although, in a broader sense, it is a continuation of the great Cordilleran system of our own country, it possesses certain marked geologic and structural differences which make it a unique and distinct province. More specifically, this province is related to the eastern ranges of the Cordilleran province of the United States; yet it is markedly different from them, as they are typified in the

Rocky Mountains of Colorado and northward. In no manner is it continuous with or allied to the California Sierras, as is sometimes supposed. In fact, the Mexican Cordilleran province is neither Rocky Mountain nor Sierra Nevadan in its affinities, but rather a folded and faulted extension of the feature known in the United States as the Colorado plateau. This proposition, here presented for the first time, requires too extensive discussion for demonstration at present, but will be more fully set forth in a more technical paper. It is sufficient to say now that the faulting attending the southern and eastern portion of the plateau grows in intensity together with folding southward into Mexico.

The province comprises a series of disconnected north and south mountain chains (separated by basin deserts) extending through the heart of the Republic from just within the border of the United States to south of the latitude of the City of Mexico. As a whole, it is a V-shaped area of mountainous elevation, which has been termed the Plateau of Mexico, the apex of the V pointing southward towards the isthmus of Tehuantepec, and the two widening limbs extending to and just across the border of the United States. The average level of the area between the limbs is about 6000 ft. The outer coastward ranges, constituting the limbs of the V, are relatively higher than the general level of the area between them, which consists in itself of many long ranges separated by desert plains. The Cordilleran province, as a whole, presents steep profiles or slopes to the Gulf on the east, and the Pacific on the south and west, and a ragged sub-horizontal profile across any section from east to west. As a whole, it is of much lower altitude to the north than at its southern end. At the north, along the border of the United States—which presents the lowest altitudes of all profiles across the North American Cordilleras—the mountain summits are not over 8000; the mountain passes (Paisano, Texas, and Dragoon, Arizona) 5000; and the basin levels 4000 ft. above tide. Farther south, the general altitude of the deserts and mountains rises, as along the tropic of Cancer (approximately through Victoria, San Luis Potosi and Zacatecas); the higher summits attain over 10,000, and the deserts 6000 ft. At the southern end of the province, the altitude of the general upland (not counting the great vol-

canic peaks, which rise above 15,000 ft.) is above, and that of the basins about, 8000 ft.

The Mexican Cordilleran province of lost ranges and basin deserts extends but a short distance into the United States, where it is represented by the Trans-Pecos Mountain groups and deserts of Southern New Mexico, so essentially different from the Plateau and Rocky Mountain country north of Santa Fe. In fact, if the international boundary had been made from the south end of the Sierra Nevada, along the Gila, and thence to just south of Santa Fe, it would have separated the two great nations of the continent into regions as distinct in their geographic, geologic and economic features as they now are in habits and language.

As a whole, the Mexican Cordilleran province may be subdivided, but not sharply, into three general provinces—the two Cordilleras of generally higher altitude constituting the limbs of the V known as the Eastern and Western Sierra Madre, and the wide expanse of mountainous plateau between them, which may be termed the Mexican Basin region.

The eastern margin of the Mexican Cordilleran plateau is a rim of mountain-crests, cumulative in altitude southward from the southern boundary of the United States and constituting a series of sierras or blocks, known as the Eastern Sierra Madre. They commence at Altuda, in Texas, on the Southern Pacific, about 100 miles north of the Rio Grande, and continue to that stream as the inconspicuous Santiago Sierra, 5000 ft. high. Across the Rio Grande, at Boquillas, it becomes the Sierra Carmen (7500 ft.); then the Frontereza, the Santa Rosa, etc., to Monterey, where the beautiful and lofty Mitre, the Silla and other members occur. Along the tropic of Cancer, between Catorce and Victoria, these mountains attain altitudes of 10,000 ft. or more.

The Mexican International railroad crosses a gap in the Eastern Sierra Madre, near Baroteran; the Mexican National climbs it between Monterey and Saltillo; the Monterey and Gulf follows their eastern foothills between Monterey and Tampico; the Mexican Central, between San Luis Potosi and Tampico; and the two roads to Vera Cruz from Mexico give magnificent cross-sections of the eastern Sierra Madre.

The western rim of the Mexican Cordilleran plateau is the

great Western Sierra Madre, a mountainous Cordillera of gigantic proportions, which has thus far defied the construction of latitudinal railways across the Republic. While attaining altitudes exceeding 9000 ft. only a short distance south of the international boundary, this remarkable orographic feature almost dies out at that line, north of which it constitutes the low mountains of southeastern Arizona and southwestern New Mexico, of the Dragoon type, crossed by the Southern Pacific at Dragoon Summit and Stein's Pass at altitudes of about 5000 ft., and dying out, a few miles north of the railroad, into the southern edge of the great Colorado plateau.

The configuration of the Western Sierra Madre, as crossed from east to west through Chihuahua, has been appropriately described by Kimball as a succession of narrow and continuous north and south ridges, with foothills separating broad and (longitudinally) remarkably continuous valleys. The whole surface thus characterized rises towards the west, while the mountains gain somewhat in height and the valleys in breadth in the same direction. The western slope, however, as seen from Sonora in passing from west to east, is rugged and steep; and there is considerable evidence that this is a great faulted zone which downthrows towards the Pacific. At the tropic of Cancer the mountains are still more lofty.

Still farther southward these ranges become so merged with the southeastward-trending Eastern Sierra Madre that they are united into a continuous and complicated mass of sierras, which may be appropriately termed the region of the union of the Cordilleras. Here they present some of the most superb scenery in the world, and precipitously end to the south in Oaxaca with a great "abfall" or jump-off, leading downward to the Tehuantepec province.

In the region of the union of the Cordilleras are also found the superb volcanoes which constitute the crowning spectacle of Mexico's majestic scenery. From a geological standpoint, these are veritable instances of Ossa on Pelion, for they are mountains of volcanic *débris*, piled upon the folded and uplifted sedimentary rocks which constitute the greater mass of the Mexican Cordilleran province.

The central portion of the Cordilleran province—the so-called Anahuac or Plateau of Mexico—is really a region of

basin desert-plains or "bolsons" and elongated sierras or "lost mountains." These plains are deserts of various width and length, completely occupying the areas between the mountain units, being of larger area in northern Mexico than to the south. The Santa Fe and Mexican Central railways follow them from Albuquerque to the City of Mexico, and the International and National railways thread great stretches of them.

This general area of Mexican deserts constitutes a basin-region somewhat analogous to, but entirely disconnected from, the Great Basin region of the United States, as found in Nevada, Utah, Western Arizona and Southern California, with which it has been confused. In fact, the North American Cordilleran area contains two great basin-regions, the Mexican and the Nevadan, which have no apparent connection with each other. More will be said concerning the basins in our geologic remarks.

Geology of the Cordilleran Province.

The mining engineer familiar with the physiography of the North American Cordilleras in Colorado is amazed, on first glancing at the mountains of Mexico, at their entirely different relief, vegetation and general aspect. Instead of the familiar brown and red sandstones, blue shales and reddish granites, covered with juniper, spruce or pine, he sees (except in the highest altitudes) barren hills of limestone and brownish volcanic rock, surrounded by vast stretches of cactus-covered desert.

The scenic and vegetal differences between the Colorado and the Mexican mountains, as well as the pursuits and habits of the people inhabiting them, are chiefly due to the rock material constituting the respective mountains. As a whole, the Mexican Cordilleran province consists chiefly of folded, faulted and uplifted limestones of Cretaceous and Jurassic age, accompanied by dikes, sills and other fissure-phenomena of igneous rock. Briefly, this material is: (1) limestones, constituting the chief mass of the mountains; (2) igneous rocks protruded through the limestones; and (3) desert *débris*, derived from the decay of the mountains.

The mountain limestone of Mexico is nearly always designated as Carboniferous, not only by the mining engineer, but by many able geologists, because it resembles lithologically the

blue and gray Paleozoic mountain limestones of the Appalachian and Cordilleran fields of the United States. This limestone is not Paleozoic, however, but mostly Cretaceous; and it constitutes the great silver-lead (and exceptionally the copper) matrix of the Mexican Cordilleran region. Furthermore, the mountain masses are largely of an older Cretaceous stage than the Cretaceous strata of the Colorado Rockies, which belong almost entirely below the Dakota horizon. These Cretaceous limestones constitute the summits of both the Eastern and the Western Sierra Madre.

Associated with the sedimentary limestones of these mountains, many igneous rocks occur as dikes, sills, indurated tuffs and other *ejecta*. These rocks (the universal "porphyry" and "granite" of the miners) are of peculiar mineral species. Throughout northern Chihuahua and Trans-Pecos, Texas, mountains of such material, which is known as *cantera*, may be seen. *Cantera* is an altered or metamorphosed quartz-porphyry cinder, consolidated and cemented (as noted by Kimball) by the influence of air and percolating waters. It oxidizes brown upon the surface, but is white before weathering. The city of Chihuahua is constructed of this material. To the southward the acidic fissure-eruptions of the north are succeeded by the great basic eruptions of the magnificent line of volcanoes accompanying the south end of the union of the Cordilleras.

It is useless to attempt to enumerate or describe the wonderful volcanic phenomena which, stretching from ocean to ocean, amaze the beholder with their grandeur and beauty. The German geologists, Felix and Lenk, have set forth at length their occurrence along lines of fissures and faulting, while Senor Ordoñez, the Mexican geologist, has made some valuable publications upon them. Orizaba, Popocatapetl, Ixtaccihuatl, Nevada de Toluca, Colima, and others, deserve each a separate volume.

The third, and not the least important, material of the Mexican Cordilleras constitutes the floors and margins of the great filled-in structural valleys, between the mountains, which I have termed the basin-deserts. This material, whether as the great sand-hills of the Medaños, the flour-dust of the Jiminez desert,

the reddish-brown *adobe*, or the snow-white *tepetate*,* is all derived from the decay of the mountains, and the depth and extent which it attains are surprising. Its cause will presently be explained.

The complicated structure of the Mexican Cordilleras has never been worked out in detail or in its entirety. Primarily, the mountains are compressional folds, which were elevated to their present great altitude by forces as yet inexplicable and uninterpreted. The salient and conspicuous features of this structure are:

(1) The existence of folds, which, in some regions, are close and vertically compressed (example, the Eastern Sierra Madre near Monterey); in others, widely arched, so as to appear but slightly deformed; and in still others, apparently tilted blocks (faulted monoclines).

(2) The apparent existence of great zones of faulting, which in some instances at least are subsequent to the epoch of greater folding, and along lines diagonal to it. Three major zones of faulting are conspicuous: the first, along the axial direction of the Eastern Sierra Madre, the detail of which has been worked out by the writer along the Rio Grande; the second, a great zone of faulting along the southern end of the Cordilleras, which has been described by Felix and Lenk; and the third, a supposed zone of faulting along the western base of the Western Sierra Madre, producing (with erosion) the western escarpment of these mountains.

The most interesting features of the geological structure of Mexico are the systems of faults (see Fig. 2) which have apparently played, in the development of the major physiographic aspects, a part so important that it may be said that all the greater aspects, such as the axial-direction of the Sierras as a whole, as well as of many of the individual ranges and desert-basins; the direction of some of the rivers, such as the Rio Grande and Pecos, above the point of their union; the lines of

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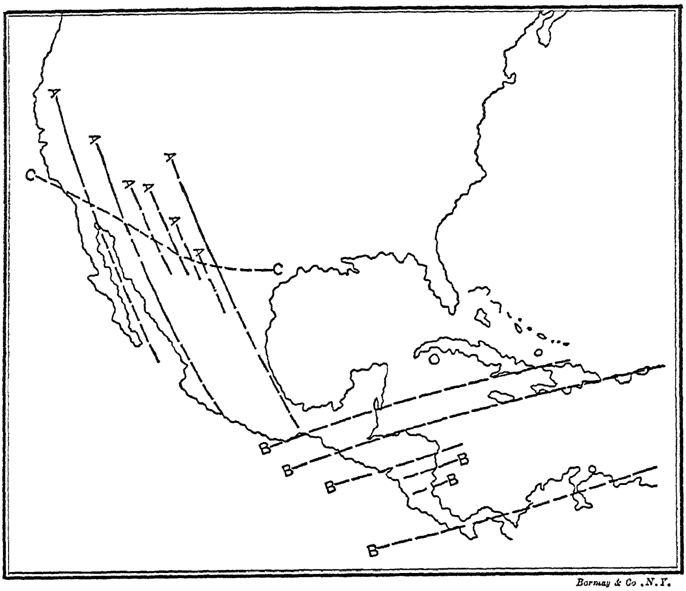
* Various local names are used for this material, such as *caliche*, *tierra blavea*, etc. In southern Mexico and Central America *tepetate* is used for volcanic tuff and ashes.

NOTE BY THE SECRETARY.—*Tepetate* is also the common miners' term for waste rock, or rubbish in a mine.—R. W. R.

the ancient fissure-eruptions; the direction of the coast line; and the present arrangement of the newer volcanoes, follow in a marked degree certain major lines of faulting.

There are three great orogenic trends in northern and tropical America, each representing a period of tremendous topographic and continental evolution, to wit: (1) the Appalachian, with axial NE.–SW. folds; (2) the Cordilleran, with NW.–SE. axes; and (3) the Antillean, or Central American, with E.–W. axes. If the Appalachian revolution, culminating after the

Fig. 2.



Bormay & Co., N.Y.

Sketch-Map of Mexico, Showing Chief Zones of Faulting and Orogenic Trends. (A, A, Cordilleran; B, B, Antillean; C, C, Minor Zone of E.–W. Faulting.)

Carboniferous period, ever affected the Mexican region, its traces and effects were obliterated by the deposition of the 20,000 ft. or more of Cretaceous strata, which still overlie the older structure. The Cordilleran revolution (at the close of the Cretaceous and in Eocene time) is the one, however, which embossed upon the peninsula of Mexico the features of the present Cordilleran province. The Antillean revolution (of Miocene time) produced the E.–W. trends of the southern coast of Mexico, Central America and the Great Antilles. The great active volcanoes of southern Mexico are supposed to be

due to fissures at the crossing of the Cordilleran and Antillean trends. Surely there has been great dislocation there. A secondary line of faulting (see *c c*, Fig. 2) crosses the Cordilleran trend from E. to W. along the southern edge of the Colorado plateau and through El Paso, Tex. This zone of fissuring, complemental to the major trend of the Cordilleran fault-axes, is inconspicuous, except that in a large number of instances the mineral veins seem to accompany these minor, instead of the major, axes. This is notably so at Sierra Mojada, Santa Eulalia, and the cinnabar mines of Texas.

While the material and structure of the mountains are important factors in producing the unique scenic and economic features of Mexico, there is a climatic element which has much to do with the creation of its unique landscapes and mineral wealth. This is the different effect of the processes of solution, erosion and transportation, as compared with those of more humid regions. In regions of ample rainfall (like the eastern United States) there is enough water to transport the rock-débris, and to carry the mineral solutions to the ocean. In arid regions (like Mexico), the moisture, while of greater solvent power, owing to the greater heat of the rock-surfaces upon which it falls, transports the lime in solution and the rock-dêbris for short distances only, because the run-off is nearly always evaporated or absorbed a short distance from the place of rainfall—usually at the margin of the deserts—and the minerals are redeposited. The storm-born torrents on the mountain-top soon die upon reaching the valley's edge, and there deposit the gravel (as *talus*-fans) and the lime-salts (as *tepetate*) which, in other regions, travel on to the sea.

The observer in Mexico is constantly confronted with two visible monuments of these processes—*karrenfelder* and *tepetate*. *Karrenfelder* are the miniature sculptures made by solution upon every limestone surface; *tepetate* is a superficial deposit of carbonate of lime, from the evaporated waters. Monterey is built of it.

The chief natural resources of the Mexican Cordilleran province are its minerals. In fact, without them most of its area would be, what it is by nature, a great desert-waste; but the existence of the mines has made possible cities, railways, and a high civilization.

The chief mineral product of the Mexican Cordilleran province is silver; it is the greatest silver district of the world, excepting the United States. A little copper and some lead are found, while iron also occurs; but all of these, except the copper, are accessories, usually associated with the silver-ore, which is largely ferruginous and accompanied by lead. It is not claimed that the limestone of these mountains is in any manner the source of the silver; its texture and structure are the factors which make possible the deposition of the ores in such great workable quantities. Furthermore, its solubility has not only made favorable cavities for ore-deposition and replacement, but its residual iron has added to the ore-value. While the igneous rocks, which everywhere more or less ramify through the Cretaceous limestones of the Mexican Cordilleras, may constitute the ultimate source of the metal for which these mountains are famous, the limestone itself is the favorable matrix in which the minerals are deposited by the circulating solutions. In its pockets, crevices, caverns, fissures and joint-planes are found nearly all the great lead- and silver-deposits of Chihuahua (notably Santa Eulalia), Sierra Mojada, Nuevo Leon, Monterey, Coahuila, San Luis Potosi (Catorce and Matehuala), Zacatecas, and other places.

A brief description of two typical localities—the silver-mines of Santa Eulalia, Chihuahua, and a copper vein near Jimulco, Mexico, will illustrate the relationship between the geology and ore-deposits of the Cordilleran province.

Santa Eulalia.—The Santa Eulalia mountain, a few miles southeast of Chihuahua, is a typical "lost mountain" sierra, rising about 1500 ft. above the adjacent plain, and composed primarily of sub-horizontal Comanche limestone, in massive strata, aggregating about 3000 ft., mantled superficially by a light-colored eruptive material (*cantera*), usually occurring as tuff and cinder. Before the *cantera* was erupted the limestone mountains existed; for the volcanic tuff fills pre-existing valleys, and dikes of the igneous material cut the Cretaceous limestone. Furthermore, caves and fissures also existed in the limestone before it was covered by the erupted material.

While the old caverns and fissures are often barren of ore near the surface, and the upper ores struck are impoverished (low-grade), this district is noted for the fact that deep mining

(1300 to 1500 ft.) has always encountered rich oxidized ore of iron, lead and silver (carbonates, sulphates and chlorides) The irregular cavities in the limestone (called chimneys, etc by miners) are merely old water-courses; and it is in thes ancient drainage-ways through the crevices of the limeston that the minerals have been deposited. These crevices ar due to water, working its way along fissures, joints and bedding-planes, all of which were enlarged by solution before th deposition of their present ore-contents. While it is impossible to say positively, without minute petrographic analysis, i seems very probable that some of the mineral elements originated by the agency of circulating waters, extracting then from the caps and dikes of igneous rocks, and redepositin; them in the old fissures of the lower-lying limestones.

The numerous bodies of silver-lead ores are all in the limestone; no contact-bodies, or bodies of ore within the igneou rock, having as yet been reported in the district. No better example of the secondary enrichment of minerals by downward circulating waters can anywhere be found than here. (See p.178.

Such is the character of many of the finest silver-lead mine in Mexico, most of which occur in the Cordilleran province In some districts, however, the ores are found on the contact between the lime and the igneous dikes (fissure-eruptives), or in exceptional instances, in the igneous rock.

Jimulco.—At a mine 10 miles southeast of Jimulco (a few stations south of Torreon) there is another interesting illustration of how the cavities in the Comanche limestone constitut a favorable matrix for the aqueous deposition of foreign minerals. In this case no igneous rocks whatever are known t occur in the vicinity, either as a cap or core to the mountains nevertheless the small cavities in the limestone are filled witl high-grade copper-ores.

The mine of the Jimulco Mining Co. is situated in a mountain range composed of Comanche limestone strata, betwee the vertically outcropping bedding-planes of which the coppe carbonate stains may be seen over a considerable area. A one place, along a fissure dipping slightly diagonal to the vertical strata, there are great chambers, in one of which 30-per cent. copper-ore (carbonates and oxides), accompanied by pulverulent specular hematite (62 per cent. of iron), was found

No igneous outcrop is to be seen anywhere in the region; and it is obvious that the ore could not have been derived from the purely marine limestone constituting the country-rock. Its only possible source has been circulating solutions from some concealed source within the great mass of mountains upon the edge of which the mine is situated. Copper deposits, however, are exceptional within the Cordilleran province.

III. The Sonoran Province.

The Sonoran province embraces the States of Sonora and Sinaloa west of the Western Sierra Madre, and that portion of Arizona lying south of the southern escarpment of the great Colorado plateau. Physiographically, this province is apparently the southern continuation of the Great Basin region of the United States as hitherto recognized, but here termed the Nevadan basin-region, to distinguish it from the great Anahuac basin, constituting the plateau of Mexico. Before presenting any opinion as final, however, it may be well to say that the region as a whole is still one of the least studied of the American provinces.

In Mexico this province is limited on the east by the great western escarpment of the Western Sierra Madre; in the United States by the western border of the Colorado plateau. The region is distinguished by low, disconnected mountains and hills, surrounded by areas of desert, and mostly lies within 3000 ft. of sea-level. In fact, the Gulf of California is probably a faulted and subsided area which was formerly a part of the Sonoran province.

Geologically, the region is quite different from the Cordilleran province, both in physiography, material, structure, and products. Although limestones do exceptionally occur, the material of the mountains is largely siliceous, argillaceous, and metamorphic, instead of being almost entirely of limestone, as in the Cordilleran province. The volcanic materials are largely acidic (rhyolitic) tuffs and porphyries. The age of the stratified rocks of marine origin is also different, consisting of Archean metamorphic schists (in Altar), a little Paleozoic limestone (in Arispe), and Triassic, Cretaceous, and Pacific Coast Tertiary to the south. In addition to these, there are vast areas of desert-débris and plateaus of volcànic tuff. In gen-

eral, the northern portion is composed of Paleozoic and older rocks, as in southern Arizona, although some Mesozoic rocks, as described by Dumble,* are found, especially to the southward.

In the district of Altar, towards the Gulf of California, there are many low hills and mountains of metamorphic rocks, cut by numerous quartz dikes. In other districts the country is capped by a vast thickness of sheet tuffs, below which, as revealed by erosion (near Magdalena and Horcasitas) there is a plexus of intensely folded mineral-bearing Paleozoic rocks.

Mineralogically, the Sonoran province of Mexico is the copper-gold field of the Republic; silver and lead being exceptional. Coal is also known to exist, but at points at present too remote from transportation for commercial use.

The Sonoran province is one of the great copper districts of the world. All the copper mines of Arizona: the United Verde, Globe, Clifton, Morenci, and Copper Queen mines, are within this province; while, just across the line in Mexico, Nacosari and Cananea are new and important producers. In fact, the Arizona copper-district, rich as it appears, is, in my opinion, but the northern extension of a far greater prospective field in Mexico. The geology of the Arizona mines has been set forth in our *Transactions*, by Wendt,† Douglas,‡ and others. It is no exaggeration to say that when the Sonora-Sinaloan copper-fields are fully developed, they will immensely increase the world's output of copper. Continuing southward, numerous copper-prospects and claims are met with in Sonora, and far into Sinaloa and Michoacan.

Cananea, a district about 40 miles SW. of Bisbee, is now attracting a great deal of capital and development. At this point a typical lost mountain rises above the desert. It is composed of a light-colored porphyritic eruptive, with some of the Bisbee limestones at its western end. Running NW.–SE. through the axis of the mountain is a great shear-zone, the cavities of which are everywhere impregnated with copper-ores—largely sulphides, although carbonates and oxides abound. A feature of this, and of the Horcasitas district, 100 miles south, is the occurrence of tremendous outcrops of iron gossan at the surface.

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* *Trans.*, xxix., 122. † *Trans.*, xvii., 483. ‡ *Trans.*, xxx., 191.

The Sonoran province was the chief source of gold before the discovery of that metal in California. For 300 years or more, placers have been worked by dry-washing processes, notably in the Altar district. The gold is derived from the schists and quartz of the adjacent hills. The profitable gold-mines of southern Arizona all lie within this province. There are many small stamp-mills and cyanide-plants in Sonora; but lack of water is a great drawback.

It may be truly said that nearly all the population of Sonora, west of the Sonora Railway, to-day lives by gold mining; perhaps the most primitive in the world. The placers are worked with crude dry-washers of the "wheat-fan" type; the quartz-veins are mined, the ore being carried on men's backs to the nearest water (often 20 miles distant), pulverized with a large stone in stone mortars, and ground and amalgamated in *arrastres* with burro-power.

IV. The Tehuantepec Province.

South of the great *Abfall* ending the Cordilleran province proper, the geologic and geographic relations are Central American in their aspects, consisting of east and west axes of older crystallines, and possibly Paleozoic rocks. This is the truly tropical region of Mexico and a different world from the rest of the Republic, the discussion of which belongs elsewhere. In it, Mexico has most valuable resources, which I regret cannot be touched upon here.

Postscript.

The proof of the foregoing article reached me in Mexico, where I have been making a more minute study of the Santa Eulalia district. I am convinced, as suggested by Mr. W. H. Weed, that the cavities are largely contemporaneous replacement. I have also learned that at least one mine in this district has ores along a contact of dike and limestone. I hope to publish a special paper on the district in the near future.

The Treatment of Clay-Slimes by the Cyanide Process and Agitation.

BY E. A. H. TAYS AND F. A. SCHIERTZ, SAN JOSÉ DE GRACIA, SINALOA, MEX.

(Mexican Meeting, November, 1901.)

I. History.

In 1893 the Anglo-Mexican Mining Company, Limited, purchased the Guadalupe and adjoining mines, and, after opening up the Guadalupe, constructed a 20-stamp mill, which was started in August, 1894.

Although the results were extremely profitable (the ore being very rich and carrying much free gold) they were not satisfactory, because the tailings were found to average about $20 per ton in gold. Early in 1895 the late Mr. James E. Mills made for the company a very thorough study of the subject, and decided that the tailings could be treated most advantageously by the cyanide process. In view of this opinion, Mr. Henry R. Batcheller, of Boston, was sent down in the winter of 1895–96 to experiment on a working scale. Mr. Batcheller was successful; and, during 1896–97, built a cyanide-plant with a capacity for treating 1500 tons per month.

This was run until May, 1899, when all the sands suitable for the process had been treated. The mill was stopped about the same time for lack of ore; but no tailings from the mill had gone to the dump since October, 1897, as the values they contained after that date were far too low to warrant further treatment. When the cyanide-plant was stopped there still remained on the dump about 16,000 tons of slimes, consisting of about 75 per cent. of clay-slimes and 25 of sand-slimes. The successful treatment of this very unfavorable material is the theme of this paper. Fig. 1 is a view of the hacienda, taken in 1897.

II. Character of the Slimes.

The slimes under consideration comprised those naturally separated from the sands at the far side of the dump, and also those mechanically separated from the sands during the first run of the cyanide-plant and returned to the dump. Of the 16,000 tons, 75 per cent. were, as already observed, pure clay-slimes of the consistency of putty. Fig. 2 shows a bank of this material, about 11 ft. high, and showing no seams of sand. All of this material would pass through a 400-mesh screen; and, although it had weathered for five years, and still contained from 18 to 20 per cent. of moisture, at least 80 per cent. of it had been unaffected by oxidation. There was evidently an absolute lack of capillary passages in it. That material which was more or less mixed with sand-slimes, or surrounded the outer edges of the main dump, or lay in piles of clay-balls or clods, screened from the sands treated by percolation, was considerably more affected by the weathering; and the degree of extraction reached in treating it was fully 10 per cent. better than after we got well into the main pile. The remaining 25 per cent of the total consisted of sand-slimes, most of which would pass a 200-mesh screen. These were found in isolated bunches above and in thin seams below the clay-slimes in the manner shown in the photographs. The original tailings were very fine, although the ore had been crushed through a screen of only 40 meshes to the linear inch. Tests made by Mr. J. A. Edman, of Quincy, Cal., gave: sands, 49; slimes, 51 per cent.* Of the sands, 10 per cent. passed over a 50-mesh screen; 30 over 50- to 100-mesh; 27 over 100- to 200-mesh; and 33 per cent. below 200-mesh.

Of course, the slimes (51 per cent. of the total sample) were all below 200-mesh in fineness; and it was stated that 80 per cent. of these would pass a 400-mesh screen.

The original ore had consisted of quartz, white or reddened with iron oxide, and a lime-rock (calcite), more or less mixed with decomposed country-rock (andesite) from the walls and from fragments incased in the ledge proper. This ore carried much free gold, some free silver at times, lead and copper sul-

* This sample was evidently taken from the dump near the discharge of the launder, and was more or less washed.

phides carrying silver and showing much free gold, zinc-blende, copper and iron pyrites, and copper carbonates. The original ore also undoubtedly contained alumina; for aluminum, which had evidently been dissolved, as well as gold, silver and copper, by the cyanide, was found by analysis in our precipitates.

The original samples of the tailings showed no trace of alumina—doubtless because they were taken, as already remarked, from near the launder-discharge, which would naturally be nearly pure sand; the slimes and clay being washed over to the far edge of the pond. Nor did those ore-samples show alumina which represented only the metal-bearing quartz. But a large part of the vein-material was replaced country-rock, with bunches of altered country-rock, all carrying gold; and in this was found the aluminum oxide.

This ore, treated by plate-amalgamation, yielded about 72 per cent. of its gold and 45 per cent. of its silver contents, and about 1.5 per cent. of concentrates, containing most of the lead, zinc and copper sulphides and iron pyrites, and part of the iron, lead and copper oxides, and a good part of the remaining gold contents (not caught on the plates, by reason of hydrated oxide coatings or adhering particles of iron oxide and quartz).

The slimes, as run onto the dump, contained, besides quartz, clay, etc., principally ferrous and ferric oxides (constituting 80 per cent. of the mineral contents), pyrites, minute portions of lead and copper sulphides, a little copper carbonate, and about $13 gold and 1.33 oz. silver, per ton. The gold was in minute particles—under 0.0025 in. in diameter—adhering to oxides or incased in fine grains of fractured quartz. The copper-content was about 0.11 per cent.

III. Experiments for Treating the Slimes by Agitation.

After all the available sands had been treated, the question was how to recover, at as small an outlay as possible, the $200,000 contained in the remaining slimes. It was desired to make use of the old plant as far as possible; and, after a couple of unsuccessful experiments, the process about to be described was tried.

In the experiments, 6 runs were made with 5-ton charges, made up half of slimes, as found on the dump, and half of

picked, pure clay. We could not take into consideration, at that time, the fact that oxidation had not been uniform throughout the entire dump; but we chose the worst combination of materials at hand, feeling sure that if good results were obtained from that, we should be sure of succeeding with all other mixtures.

Our experiments proved that the mineral could be readily dissolved; that the KCy solutions acted rapidly on the values contained in it; that a good settling could be effected by the use of sufficient solution and lime; that 90 per cent. of the values extracted could be decanted with two washes; and that a charge could be put through in 24 hours, giving an extraction of at least 75 per cent. of the values contained, at a cost of about $5 gold per ton.

Upon obtaining these results, we were instructed to make the necessary alterations in the old plant and to proceed with the treatment of the remaining slimes.

IV. The Plant as Altered.

Of the 10 vats of the original plant, 20 ft. in diameter and 5 ft. deep, holding each 50 tons of sands, 6 were fitted up with ordinary agitating machinery, so as to be nothing more than enlarged settlers of the pan-mill type; and 4 were used as storage-tanks—2 for the made-up solution and 2 for the decanted solution containing the gold. There was a belt elevator for raising the slimes up to a mixing-trough from which they were run to the agitators in V-shaped launders. There were also 2 solution-tanks and 4 receiving-tanks. The whole plant was run by a 60-H.P. engine; and a 60-H.P. boiler furnished steam, not only to the engine, but also to a large pump which supplied the plant with water, 4 solution-pumps and the filter-press pump. Steam was maintained, generally, at 80 lbs.; and, as a rule, 3 cords of wood were consumed in 24 hours.

The precipitating-room was fitted up with the usual zinc-boxes, filter-press and acid-barrels. Light was furnished by a small electric plant driven by steam. The zinc-shavings were turned on the premises.

Under favorable conditions this plant could treat 1700 tons per month; but of heavy clay-slimes only 1500 tons could be run through to advantage.

V. The Process.

As the slimes, for the most part, presented a stiff bank of clay from 4 to 11 ft. deep, they could not be shoveled directly into the cars, but first had to be sliced off in very thin slices, cut up as fine as possible, and mixed with as much of the sand-slimes as could be had at hand; after which, the material was shoveled into half-ton cars and trammed to the scales. In order to keep it as nearly uniform in character as possible, it was taken from four different parts of the dump at once.

At the scales a sample was taken from each car by running a half-round, grooved sampler, 1 in. in diameter and 5 ft. long, diagonally through the load, from one end. These samples were put into a covered tin can, and amounted, for the 100 or 116 cars treated daily, to between 55 and 60 lbs. This total was dried and the moisture was calculated before assaying. The moisture usually ran between 18 and 24 per cent.; the latter, directly after a heavy rain; the former, even in the driest season.

From the scales the cars were trammed about 60 ft. to the elevator-pit, under the tank-floor, where they were dumped, and thence raised to the top of the building, at the rate of about a ton in five minutes, by a belt-elevator set at an angle of about 60°. The elevator-cups discharged into a sheet-iron box-trough, 4 ft. long, 1 ft. wide on bottom, 2 ft. high at the elevator-end, and 1 ft. at the discharge-end. Here the slimes were met by two streams of solution, discharged vertically downward through a 1-in. pipe at the upper end of the trough. The main solution-pipe was 2 in. in diameter; and the solution was pumped up from the lower solution-tanks and discharged under pressure. At first one jet was discharged vertically and the other horizontally against the slimes, as they fell into the receiving-trough; but we found the two vertical streams to give the best results.

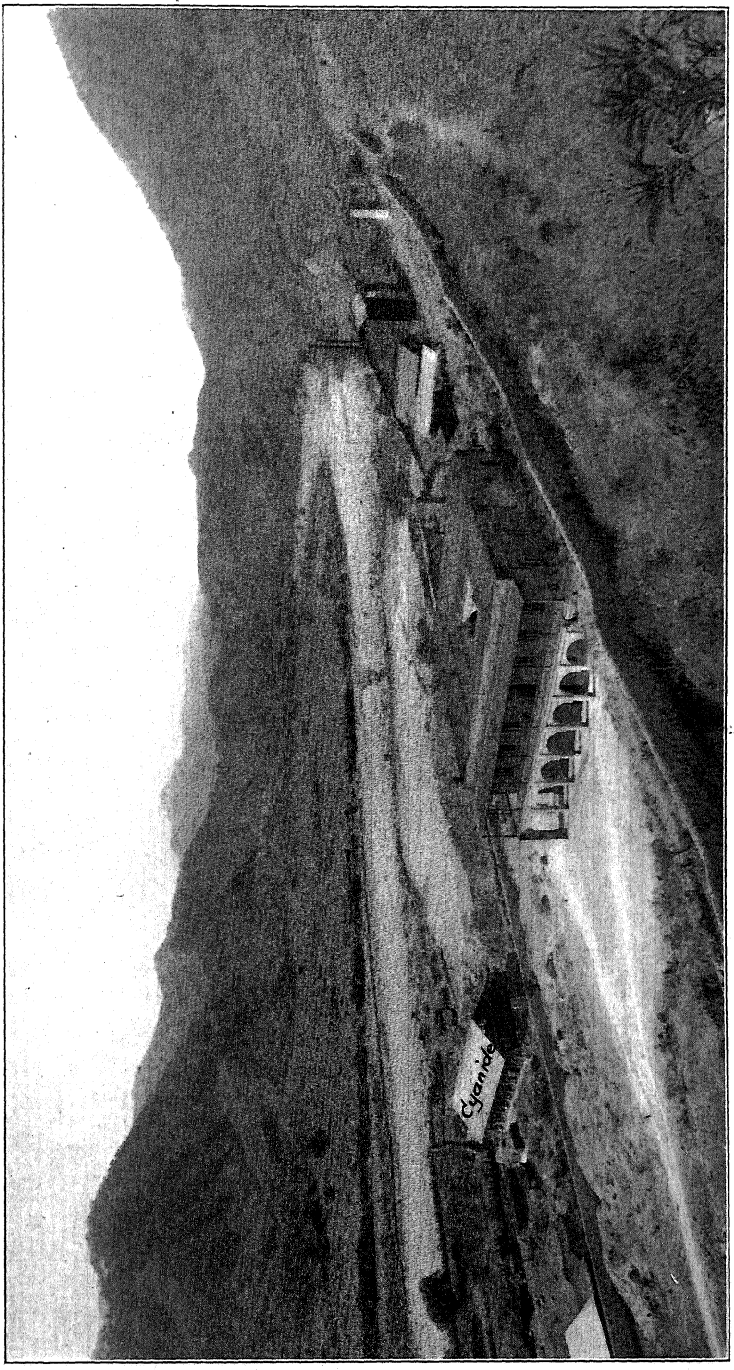
From the receiving- or mixing-trough, the mixed slimes and solution were run into the agitators by means of three V-shaped launders made of 1-in. boards, 12 in. wide. These launders had a fall of 1 ft. in 5, and each fed two agitators; the material conveyed being delivered to the agitators in the ratio of 1 part of slimes to 1.5 of solution.

Solution.—The solution was made up in the two sump-tanks, 20 ft. in diameter and 5 ft. high, set up in a pit at a level lower than the zinc-boxes, and 15 ft. lower than the agitator-floor. In our tests, solutions were used containing from 0.10 to 0.30 per cent. cyanide. All gave good results, but showed a consumption of cyanide of from 7 to 8 lbs. per ton. This had been the case also when the sands were treated; and in the original experiments made by Mr. Mills it was found that, if the cyanide-process were employed, the chemicals alone would cost about $3.50 gold per ton. In our experiments, at first, we found that titrations indicated but a slight consumption of cyanide, although the assays showed a good extraction; but this was due to the addition of lime to the charge at the start. Afterwards, when lime was added at the beginning of the last hour's agitation, we noticed that the titration made after such addition showed from 0.02 to 0.08 per cent. higher than the titration made just before the addition of lime. To test what effect the lime had on the titration of the pure solution, lime was added to a sample carrying 0.30 per cent. of cyanide. After thoroughly incorporating the lime and allowing the mass to settle, titration showed 0.45 per cent. of cyanide.

For awhile, after beginning to treat the slimes, we used a standard strength of 0.20-per-cent. KCy with good results, but finally dropped to 0.15 per cent., which gave us the best general results, involving a steady consumption of about 7 lbs. of cyanide to the ton of slimes treated. After passing 0.20 per cent., the consumption of cyanide increased and the extraction of gold decreased. A 0.25-per-cent. solution, used for 20 days on the same general character of slimes, showed a consumption of 8.75 lbs. of cyanide per ton and an extraction of but 74.98 per cent. of the gold and silver, while the 0.15-per-cent. solution used in the succeeding month showed a consumption of 6.21 lbs. cyanide, with an extraction of 78.56 per cent. of the gold and silver. The values of heads in these cases were $13.34 and $13.59, respectively.

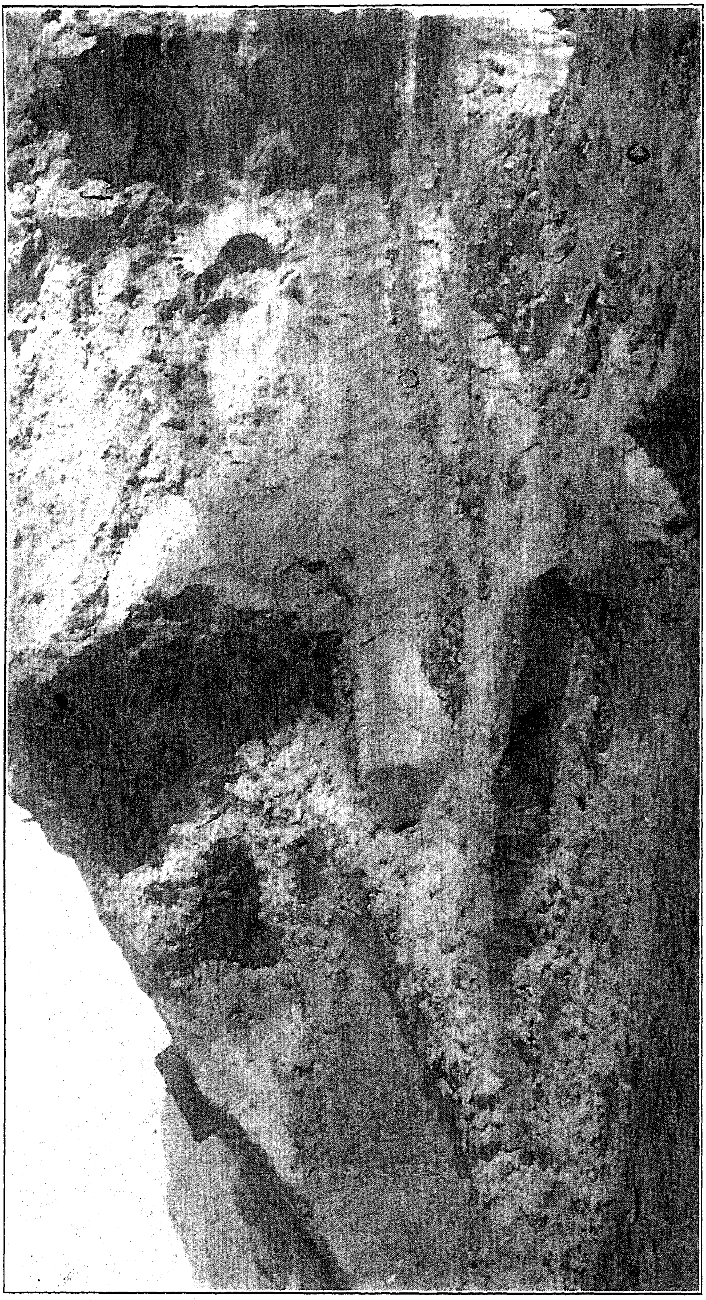
Analyses of the solution showed that it carried the metals and minerals shown below, and in the proportions given.

No. I. represents the solution as drawn off at the beginning of the decantation. No. II. is from the discharge of zinc-boxes when No. I. was supposed to be running through.



Hacienda of the Anglo-Mexican Mining Co., San José de Gracia, Sinaloa, Mexico, 1897.

FIG. 2.



Bank of Pure Clay-Slimes, carrying about 18 per cent. of Moisture.

	I. Grammes per Metric Ton.*	II. Grammes per Metric Ton.*
Cu,	422.9	293.2
Fe,	nil	nil
Al,	32.5	34.8
Zn,	209.5	120.5
Ca,	458.0	384.8
Insoluble residue,	38.5	38.0
Au,	4.82	0.03
Ag,	6.50	0.08

This solution had been in use for about 10 months.

Agitation.—As already remarked, the old tanks, 20 ft. in diameter by 5 ft. deep, were utilized for this purpose by introducing the machinery of an ordinary settler, modified to suit the use to which they were to be put. The inside cone stood 4.6 ft. from the floor of the tank, and was bolted to a ¾-in. plate, 3 ft. in diameter. This, in turn, was bolted to the bottom of the tank, which was 3 in. thick.

On top of this cone sat a muller with four 9-ft. arms, which were set 7 in. above the bottom of the tank, when the muller was down. To each of these arms were bolted, at an angle of 30°, three wooden shoes, 6 by 8 by 36 in. in size. The outside and inside shoes had a 1-in. strip nailed to the bottom, while the center shoe was left 1 in. higher; since we found that stray rocks, gravel, etc., gathered there, and in this way, not being caught by the arms as they revolved, did little damage. The mullers were arranged so that they could be raised 3 ft.; and, after we got to running regularly, they made 9 revolutions per minute. At first, we had them make 14 revolutions, but soon found that speed to be too great, as it caused the charge to foam excessively, even with 3-in. wings.

At equal intervals were placed four wings, 3 in. wide, 2 in. thick and 4.5 ft. high. During the first experiments these wings consisted of 2-in. plank, 12 in. wide and 5 ft. high, hinged to the inside of the tank; to this was bolted a 4-ft. piece of 2-in. plank, horizontally, at a height that would just clear the top of the muller-arms when down and in motion. This was set at

* SECRETARY'S NOTE.—A metric ton being 1,000,000 grammes, these figures can be converted to the usual form of statement in percentage by moving the decimal point four places to the left. Thus, 522.9 grammes per ton would be 0.05229 per cent., etc.

any angle desired; and, when the muller was to be raised, could be turned in against the side, out of the way. But it was found to give too much resistance to the current, producing much foam. The horizontal arm was then taken off and the vertical, movable wing used alone. This was gradually swung back against the side of the tank until the edge alone offered resistance to the current. This, although but 3 in. out, was ample; so, after that. strips 3 in. wide were screwed against the sides and used up to the end of the run.

To prove that these wings were necessary, we had one charge run without them. The outer surface of the charge rose about 12 in. higher than the center, and the general surface was smooth; whereas, with the 3-in. wings the charge was level clear across, while in motion, and the whole surface was kept in constant ebullition; the currents starting from each wing making chords subtending more than one-third of the circumference. That agitation was perfect was proved by numerous samples taken from the surface of a charge while in motion, and from the same while discharging from the bottom.

The Charge.—The slimes and solution, as mixed (1 : 1.5), were delivered to the agitators in motion, about 5 tons of clear solution having been previously charged—though this was not absolutely necessary, as the amount of solution necessary to make up the charge could be, and often was, added at the last. The aim, however, was to have the charge about as it should be at the time the last slimes were run in.

As a rule, charging occupied about 50 minutes, and there were charged to each agitator about 18 car-loads, containing in all about 11 metric tons of moist slimes and 28.5 tons of solution, or a total of about 39.5 tons. This would bring the charge to within 8 in. of the top of the agitator.

The total charge thus consisted of 1 slimes to 2.6 solution; but since, as a rule, the slimes contained 18 per cent. of moisture, the charge was really 1 slimes (dry) to 3.4 solution. This proportion was observed for slimes containing more than 75 per cent. of clay. Where there was more sand, we got an excellent settling with charges running 1 slimes (dry) to 2.6 solution.

The charge was agitated five hours from the time when charging began. This period was found to be ample, as the following tables of extraction will show:

TABLE I.—*Rate of Extraction with a* 0.20-*Per-Cent. KCy Solution.*

(Charge, 10 tons slimes; 18 tons solution. Samples every 2 h. from surface.)

Test No. 2, April 15, 1900.

Hours.	Gold. Grammes per Ton.	Silver. Grammes per Ton.	Remarks.		
0	22.20	37.80			
1.30*a*	12.00	20.00	*a* Finished charging.		
3.30	7.20	15.20			
5.30	6.80	14.20			
7.30	6.20	12.80	Tailings. Assays per Ton.	Gold. Grammes.	Silver. Grammes.
9.30	5.80	12.20			
11.30	5.60	11.20	First tails discharged, .	5.20	12.00
13.30	5.40	10.60	Last " " .	5.00	11.00
15.30	5.00	9.60	Average, . . .	5.10	11.50
17.30	5.60	12.40	Extraction: Gold, 77; silver, 69.57 per cent.		
19.30	6.00	10.80			
21.30	5.60	11.20			
23.30	5.40	11.00			

It will be noted that 45.94 per cent. of the gold and 47.1 per cent. of the silver had been extracted by the time the charge was run into the tank—1 h. 30 m.; and 2 h. later, 67 per cent. of the gold and 60 per cent. of the silver had been extracted.

TABLE II.—*Rate of Extraction with a* 0.10-*Per-Cent. KCy Solution.*

(Charge, 10 tons slimes, 60 per cent. clay and 40 sand-clay slimes; 20 tons solution. Samples every 2 h. from surface.)

Test No. 3, April 18, 1900.

Hours.	Gold. Grammes per Ton.	Silver. Grammes per Ton.	Remarks.
0	21.20	39.20	*a* Finished charging.
1.20*a*	7.20	19.20	Maximum extraction evidently reached.
3.20	6.00	14.40	Tails assayed 4.60 grammes gold and
5.20	6.40	14.60	10.40 grammes silver per ton.
7.20	6.00	12.00	Extraction: Gold, 78.3; silver, 73.72 per
9.20	6.00	10.40	cent.

It will be noted here, also, that by the time the charge had been run in—1 h. 20 m.—66 per cent. of the gold and 53.5 per cent. of the silver had been extracted. This was undoubtedly effected by running at high speed through the troughs from where slimes and solution mix, to the agitator, and by the agitation during charging.

TABLE III.—*Rate of Extraction with a 0.30-Per-Cent. KCy Solution.*

(Charge, 10 tons clay-slimes; 20 tons solution. Samples every 2 h. from surface.)

Test No. 4, April 20, 1900.

Hours.	Gold. Grammes per Ton	Silver Grammes per Ton	Remarks.
0	21.00	28.20	
1.50*a*	5.20	14.80	*a* Finished charging.
3.50	3.50	8.60	Tails assayed 4.20 grammes gold and 9.20 grammes silver per ton.
5.50	4.40	10.80	
7.50	5.20	11.60	Extraction: Gold, 84.8; silver, 67.4 per cent.
9.50	4.00	9.20	

This test shows that the extraction had virtually ceased in 4 hours.

TABLE IV.—*Rate of Extraction with a 0.22-Per-Cent. KCy Solution.*

(Charge, 5 tons clay-slimes; 15 tons solution.)

Test No. 5, April 21, 1900.

Hours.	Gold. Grammes per Ton.	Silver. Grammes per Ton.	Remarks.
0	22.00	38.00	*a* Finished charging.
0.45*a*	6.20	17.00	Discharged tails assayed 3.80 grammes gold and 8.20 grammes silver per ton.
2.45	5.00	13.10	
4.45	3.60	9.80	Extraction: Gold, 82.73; silver, 78.42 per cent.
6.00	4.00	11.20	

This charge was agitated but 7 hours from the start. In 45 minutes the charge was in, and samples taken showed that 71.81 per cent. of the gold and 55.26 of the silver had gone into solution. Extraction had virtually ceased in 4.75 hours from the start. In this test two samples were taken of the tails at the same time, one to be washed and the other to be dried as it was.

The washed sample assayed, gold 3.80 grammes, Ag 8.20 grammes.

The unwashed sample assayed, gold 6.00 grammes, Ag 11.60 grammes.

This gave an actual percentage-extraction of 82.73 Au and

78.42 Ag, and a product obtainable of 72.72 Au and 69.47 Ag. This would show a loss of 2.20 grammes of soluble gold, and 3.40 grammes of soluble silver per ton. In the regular work the soluble gold lost was about 1 to 1.5 gramme per ton.

The above data, and others obtained from similar tests, led us, when we began the regular treatment, to agitate the charges only 5 hours.

Lime.—Half an hour before stopping the agitation, 5 lbs. of slacked lime was added per ton of slimes in the charge. Many tests were made with amounts varying from 2 to 15 lbs. per ton; but we finally settled on 5 lbs. as a safe mean. That the addition of lime is necessary to produce settling will be seen later. That it affected the solutions by vitiating our titrations has been shown. We fully demonstrated that, whether the lime was added at the beginning or near the end of the agitation, made no difference in the settling.

In the old treatment of the sands, so much trouble was given by foul solutions, that every few months the solution on hand had to be thrown away. We were never bothered in this way throughout the whole run of eleven months on slimes; and we attributed this result to the use of lime, which undoubtedly promoted settling and neutralized the acidity of the slimes.

Settling.—After the charge had been agitated 5 hours it was allowed to settle 7 hours. In this part of the process we made many experiments, and were kept continually on the alert in order to obtain the best results; since upon good settling depended the whole success of the treatment. Our aim was to secure a settling that would allow us to decant at least 70 per cent. of the solution perfectly clear. We found lime absolutely necessary with charges that were proportioned at less than 4 solution to 1 slimes. A charge consisting of 10 tons of slimes and 20 tons of solution, to which lime was not added, had not settled one inch at the end of 2 hours. A large sample of this charge was taken after agitation had been started, and experimented upon by the addition of water. When the proportion of 1 slimes to 4 water was reached, settling was rapid. Acting on this hint, we made the charge 1 slimes to 3 solution and added 7.5 lbs. lime per ton of slimes. This, after agitating one hour, was allowed to settle with the following results: In 1 h. it had settled 5 in.; in 2 h., 10 in.; in 3 h.,

12 in.; in 4 h., 13 in.; in 5 h., 13.5 in.; in 6 h., 14 in.; in 7 h., 15.5 in.; and in 8 h., 16 in.

In practice it would tax any plant to handle the volume of liquid that 1 to 4 would produce, which, with the "wash," would be nearly 6 tons of solution for every ton of slimes treated; but with the judicious use of lime, as good settling as can be got from clay-slimes can be obtained with a charge not exceeding 3 solution to 1 slimes. But 25 per cent. of sand-slimes in the charge would make a great difference. Material of that character should not need more than 2.5 of solution to 1 of slimes.

We found that the pure clay-slimes charge at 1 to 2 would not settle even when 20 lbs. of lime to the ton of slimes had been added; but when the charge was made 1 slimes to 3 solution, the settling was rapid. As has been stated, our regular charge, where we used a mixture containing not more than 75 per cent. of clay, was 1 slimes to 2.6 solution; although, at times, we had to raise this to 1 slimes to 3.4 solution, even when lime was used. Even when the clay-slimes settled, it was not very rapidly. In the 7 hours allowed they would only settle 17 inches; whereas the clay-sand slimes (70 per cent. clay) would settle from 22 to 24 inches in the same time. At the former rate of settling, but 81 per cent. of the values actually held in solution could be decanted (two decantations, as will be seen, being made from each charge), while the latter rate gave 91 per cent. decanted—a difference to be appreciated.

During the greater part of the run, when we had our average character of material, the charges would deposit as much as 12 inches during the first hour. These charges would begin settling from the moment the agitators were stopped, often settling 0.25 in. by the time the charge ceased going around.

During the last three months of the run a charge would rarely settle over 6 in. during the first hour; and often, not more than 4 in. Even at this slow rate, the settling would reach 19 in., as a rule, inside of the 7 hours allowed.

The records of settlings from tests made at different times may be of interest (see Table V.).

During the treatment we had several chances of testing the settling-rate for 30 consecutive hours. Some of these data

were unfortunately mislaid, but the following tables will give an idea of their character.

The difference will be noted in the rate of settling in the different tanks at the same time.

TABLE V.—*Tests of Settling with Lime.*

Test Made April 18, 1900.

Charge: 1 slimes to 2.5 solution. Slimes, 10 tons; 15 lbs. of lime to 1 ton of slimes added as soon as charge was in.

SETTLING.

Hours.	Inches.
0.5,	3.75
1,	5.5
2,	10
3,	15
4,	18
4.5,	19

Decanted clear, 62.5 per cent.

Test Made April 21, 1900.

Charge: 1 slimes to 3 solution. Slimes, 5 tons; 20 lbs. lime added per ton slimes.

SETTLING.

Hours.	Inches.
1,	5
2,	10
3,	12
4,	13
5,	13.5
6,	14
7,	15.5
8,	16

Decanted clear, 85.33 per cent.

TABLE VI.—*Rate of Settling in Different Tanks.*

(Test made March 1, 1901; charges Nos. 1022 to 1026; first settling 31 h., second settling 6 h.)

Tank No.	First Settling. In.	Second Settling. In.
1,	29.50	24.50
2,	30.00	24.00
3,	29.00	23.50
4,	28.50	23.00
5,	27.50	22.50
Average,	28.90	23.50

Total extraction of values held in solution by two decantations, 91.6 per cent. Ordinary decantation at the time, 86.3 per cent.

This run was on our most favorable material—that containing at least 25 per cent. of sand-slimes; and the charge was made up of 10.878 tons of slimes and 27.158 tons of 0.15-per-cent. KCy solution, making the proportion 1 slimes (wet) to 2.5 solution; or (moisture being 17.6 per cent.) 1 slimes (dry) to 3.25 solution. In the first settling 5 lbs. of lime per ton of slimes was added, and in the second 2.5 lbs. per ton. Unfortunately the test-sheet was lost; but the second settling shows

TABLE VII.—*Rate of Settling in Periods of Three Hours.*

(Test made May 2, 1901; tanks settled for 30 h.; rate taken every 3 h.; material of the worst clay, nearly all clay-slimes containing, in the driest and hottest month in the year, 19.2 per cent. moisture, after having lain exposed for five years. Charge, 1 slimes (dry) to 3.3 of 0.15-per-cent. KCy solution. Lime added: 5 lbs. per ton of slimes.)

Hours.	Tank 1.	Tank 2.	Tank 3.	Tank 4.	Tank 5.	Tank 6.
	In.	In.	In.	In.	In.	In.
3..........	11	12	10 5	7	6	7.5
6..........	16.5	16	17	16	15.5	10
9..........	19.5	19.75	19	14.75(?)	15.25	12.5
12..........	22	18(?)	19	20	16.25	13.5
15..........	24	20	19	19(?)	19	15
18..........	24	22	23	21.5	19.5	15
21..........	23.5(?)	22	23	21.75	19.5	15.5
24..........	23.5	22.5	23	21.75	20	15.5
27..........	24.5	22.5	24	21.5	22.5	16
30..........	24.5	24.5	24.5	23	23.5	18

At 7 hours, tank No. 1 had settled 19 in.
Tank No. 6 had but two-thirds the regular charge.
In decanting, tanks settled 0.5 in. more.

that the first had deposited at least 24 in. in the 7 h. usually allowed.

Table VIII. represents our worst work. Considering the material, the wonder is that it could be made to settle at all, with a reasonable proportion of solution.

Decantation.—After settling 7 hours the clear solution (from 14 to 18 tons) was decanted. This usually took about 1.25 hour. At first we drew off the clear solution through a double row of 3-in. holes set in "criss-cross" order for about 3 ft. up the side of the tank; but, by reason of the irregular settling, we soon found that this would not do, since we often had to leave a couple of tons, or more, of clear solution in the tank. At the suggestion of our machinist, we then ran through the side of each settler, about 1 ft. from the bottom, a 4-in. pipe, connected it by a loose elbow at the inside end with a 3.5-ft. length of pipe, set out of reach of the arms, and kept vertical while the charge was in agitation. After settling had taken place, the stand-pipe was let down gradually into the clear solution, until this was decanted down to the slimes. The 4-in. pipes from all the settlers discharged into a receiving tank set on the floor below the agitator-level. While 80 per cent. of the solution

TABLE VIII.—*Rate of Settling During 30 Hours, for Each Hour.*

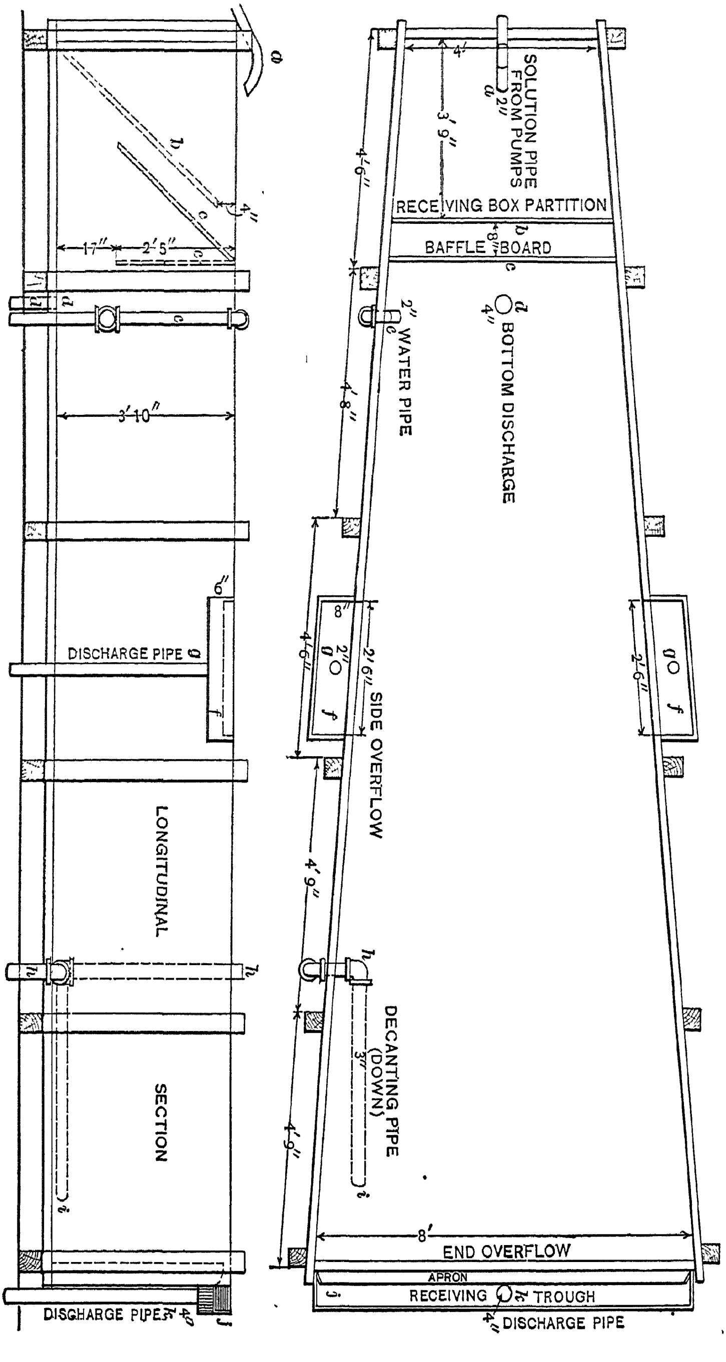
(Test made June 27, 1901.)

Hours.	No. 1.	No. 2.	No 3.	No 4.	No. 5.	No 6.
	In.	In	In.	In.	In	In.
1..........	3.5	3.5	4.5	4.5	4.5	2.5
2..........	6.5	9	13	10	7	7
3..........	14	16	17	14	15	9.5
4..........	17	18	18	15	16.5	10.5
5..........	18	19	18	16	17.5	11
6..........	19	19	19	17	19	11.5
7..........	19	19	20	17	20	12.5
8..........	19	19	21	18	21.5	13
9..........	19	19.5	21.5	19.5	21.5	14
10..........	19	20	22	20	22	14
11..........	20	22	22	20	22.5	14
12..........	21	22	23	20.5	22.5	14.5
13..........	21	22.5	24	20.5	22.5	14.5
14..........	21.5	23	24.5	20.5	22.5	14.5
15..........	22	23.5	24.5	20.5	23	14.5
16..........	22	23.5	24.5	20.5	23	15.5
17..........	22	24	24.5	20.5	24	16
18..........	22	24	25.5	22.5	24.5	16
19..........	22	24	26	23	25	16.5
20..........	22	24.5	26	23	25	16.5
21..........	23	25	26	23.5	25.5	16.5
22..........	23.5	25.5	26.5	24.5	26	17
23..........	24	25.5	27	24.5	26.5	17
24..........	24	26	27	24.5	26.5	17
25..........	24.5	26	27	24.5	26.5	17
26..........	24.5	26.5	28	24.5	26.5	16.5
27..........	24.5	26.5	28	24.5	26	16.5
28..........	25	26.5	28	25	26.5	17
29..........	25	26.5	28	25	26.5	17
30..........	25	26	28	25.5	27	17

These charges consisted of at least 80 per cent. pure clay, and were made up of 1 slimes (wet) to 2.87 solution. The slime-charge was 9.914 metric tons (1000 kilos) containing 16.9 per cent. moisture. This would reduce the dry metric tonnage to 8.238 (9 tons avoird.), which would make the charge 1 slimes (dry) to 3.46 solution. Even at these proportions, the nature of the material was such that settling was very poor; barely 50 per cent. of the solution being decanted clear, after 7 hours' settling, with the addition of 5 lbs. of lime per ton of slimes.

would run off very rapidly, the last portion (say 3 or 4 tons) drained off very slowly, and with it would come more or less fine slimes, which subsequently made trouble in the zinc-boxes —not by hindering precipitation, but by increasing the bulk of the precipitates, and interfering with their reduction to bullion. To overcome this difficulty, we put over the two gold-solution storage-tanks a large settling-box, which will be described in its place. (See Fig. 3.) From the receiving-tanks the solution was pumped up to this settling-box, whence it ran to the gold-solution storage-tanks, and thence to the zinc-boxes.

Fig. 3.



Plan and Vertical Longitudinal Section of Settling-Box.

When all the clear solution from the first charge had been decanted, water was charged (agitation having been started again) in equal amount to the solution decanted, and the agitation was continued one hour, or for about 15 minutes after the wash-water had been charged. We used water mostly as a wash; but when we had an excess of weak solution (that which had been through the zinc-boxes) we used it as a wash or second solution. As soon as the wash was charged, 2.5 lbs. of lime per ton of slimes was added. This was not needed in all charges, but to make sure, it was added, as it could do no harm. After agitating one hour, as stated, the charge was allowed to settle 6 hours, when the clear solution, usually in amount equal to the first decantation, was decanted in the manner already described.

Water was then added to the charge, in agitation, until it was thin enough to run, when it was discharged through a 4-in. opening in the side.

Discharge.—When first arranged, a 6-in. flange was bolted to the side of the agitator, so as to bring the hole on a level with the bottom. Into this flange was placed a nipple, on which was put an elbow just tight enough to turn with ease; and into this elbow was set, at an incline of about 20°, a 3-ft. length of 6-in. pipe, which discharged into a large V-shaped launder, running between the tanks, under the floor. This launder carried away the pulp.

Into the end of the discharge-pipe a big plug was driven, over the end of which a stirrup would drop, to hold it in place. This plug was secured by a chain to the floor, to prevent its being carried away by the charge, when knocked out. We soon found that the 6-in. discharge was hard to control while discharging; so a plate with a 4-in. hole in it was bolted over the opening, inside the tank. This gave perfect satisfaction; and 10 tons of slimes could be run out inside of 30 minutes.

As soon as a tank was discharged, water was run in and the tank washed out. About one hour was required from the time of starting to run in the water until the tank was ready for the next charge. The whole operation of treating a charge of 10 tons of slimes occupied about 23 hours. The 6 agitators would be charged by noon every day, and on the following day each would be discharged and cleaned, ready for a new charge, about one hour before the time for charging it.

Tails-Samples.—About 2 ft. from the end of the discharge-launder was a 1.5-in. hole through the side, tapping the bottom. Five minutes after a discharge began, two tails-samples (1 liter each) were taken at this hole: one to be washed and dried, to show total extraction; the other to be evaporated, to show actual recovery and soluble gold.

When we were experimenting we made many tests on taking tails-samples, sampling one charge every five minutes from the start to finish of discharging. These samples were so nearly uniform in value that it was seen that any one of them would have given practically the same results.

We also found that samples taken from the surface of the charge, while in agitation, checked well with samples taken from the discharge-launder. The agitator was always kept going until the charge was out and the tank washed.

Settling-Box.—In decanting we could draw off 80 per cent. of the settled solution perfectly clear; but with the remainder, small thread-like streams of slimes would be carried over also; and these, though seemingly insignificant when mixed with all the solution, sent a somewhat turbid solution to the zinc-boxes, notwithstanding the considerable settling which took place in the storage-tanks. To obviate this difficulty we put in a large settling-box, which helped matters materially. Fig. 3 shows the form and dimensions of this box. The solution, after decanting, as already described, was pumped up from the receiving-tanks to the settling-box at the rate of about 125 gals. per minute. The discharge-end of this box was 8 ft. across, and the surface-current was nothing to speak of, up to within the last foot of the discharge; so that although the solution, run over into the storage-tank, still carried some slimes in suspension, the quantity was so small that a beakerful, settling over night, would show barely a trace on the bottom.

After we had put in the settling-box, we used to draw off the clear solution as close as possible, even if more or less fine slimes did come off at the end. The whole secret of settling is: to make sure, first, that all suspended matter shall be thrown towards the bottom; and, second, that the flow over the edge of discharge shall be so thin as to reduce the current to a minimum. The first of these objects is secured by means of a baffle-board near the intake end; and the second, by either

governing the amount of liquid run through the settler or by increasing the width of the overflow so that the stream shall occupy it fully, in the thinnest of sheets.

We found that 125 gals. per minute was a little too much for even the 8-ft. discharge to handle, as the overflow was nearly 0.125 in. deep. An overflow 2.5 ft. wide was then cut on each side, at the same level as the end-overflow, as shown at *g*, *g*, in Fig. 3, a little back of the center of the box. This gave very good results, and, with the aid of other arrangements in the storage-tanks, sent the solution to the zinc-boxes with very little suspended matter.

Before the side-overflows were put in, the surface-current was measured, and found to amount to 125 gals. per min., with a velocity of 10 ft. in 6 min. from the head of the box; the next 15 ft. in 8, and the next 20 ft. in. 9.5 minutes. After the side overflows were put in, the rate and direction of surface currents were established as shown in Fig. 4.

The float for testing the currents in the settling-box was half a match, a new piece being taken at every trial.

No. 1, after many delays and changes in direction, went over the left-hand side-overflow in 15.33 min. Nearly two-thirds of the time was taken in covering the first third of the distance.

No. 2, after starting for the baffle-board, turned back and, running around the starting-point, headed for the right-hand side-overflow, going over in 8.25 minutes from the start.

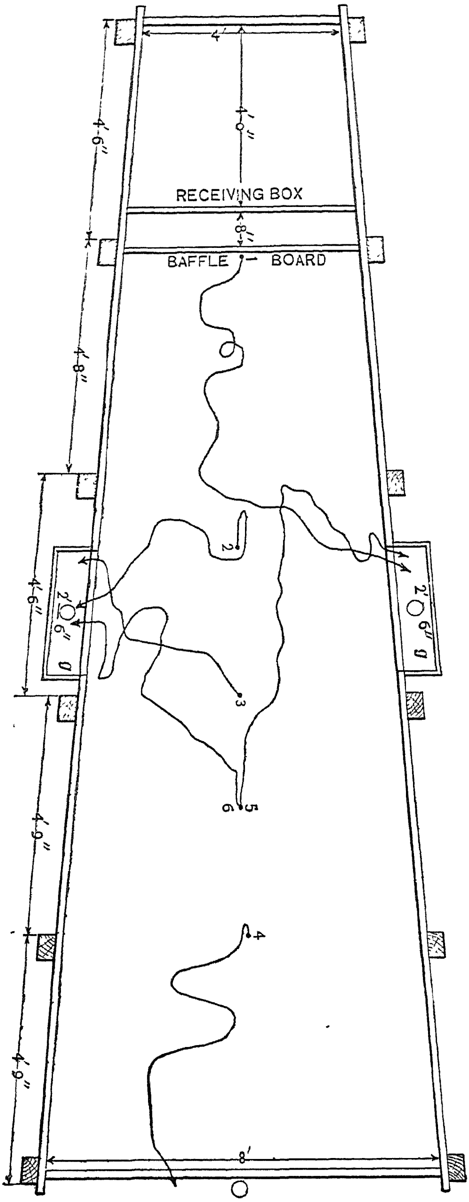
No. 3 started at once for the right-hand side-overflow, and went over in 3.25 min.

No. 4 started back towards the head, was stationary a short time, then turned and made its way, zig-zag, to the end-overflow, going over in 6 min. from the start. There was a notable increase in speed within the last 4 in.

No. 5 started straight up towards the baffle-board, but within 2 ft. from the start was caught by a slight draft and carried very rapidly about two feet farther in the same direction; it then continued in the same course up to the first set of braces from the baffle-board. Here it turned, taking the same general direction as No. 1, and went over the left side-overflow in 6 min. from start.

No. 6 was a repetition of No. 5. It started straight up towards the baffle-board for a little over a foot; there it wavered

a moment, and then headed direct for the right-hand side-over-flow. When two-thirds of the distance to this had been run, it



Plan, Showing Surface-Currents in Settling-Box, Fig. 3.

FIG. 4.

started up towards the head and center. When opposite the center of the right-hand side-overflow, it headed for this, but

gradually swung down stream until opposite the lower end of the side-overflow, when it turned back, and when opposite the center turned and went over, in 5.33 min. from the start.

The box was cleaned out every 15 days, and the accumulated silt on the bottom was found to be rather compact, although soft, after the supernatant solution had been decanted. The accumulated slimes would amount to about 1.5 tons; and as 200 tons of solution, more or less, were run through daily, this would make the amount of slimes held in suspension equal to about one lb. to the ton. By using this box we were enabled to draw off the settled solution in the agitators much closer than we could otherwise do, and yet send the solution to the zinc-boxes carrying less suspended matter than before.

The box had a 4-in. discharge, for washing it out, in the center of the bottom, immediately in front of the baffle-board, and a decanting apparatus on one side, within 5 feet of the discharge-end. A 2-in. water-pipe, entering it over the side, near the baffle-board, furnished water under pressure to wash it thoroughly, after the slimes had been shoveled out.

Storage-Tanks.—Two of the original sand-tanks, 20 ft. in diameter and 5 ft. deep, were fitted up for storage-tanks, from which the solution was run to the zinc-boxes. These were in line, at the end of the line of tanks nearest the precipitating-room, and connected, on a line with the bottom, by a 4-in. pipe. The settling-box discharged through a 4-in. pipe into the farthest of these two tanks (No. 1), the pipe being carried straight down to the bottom, and discharging horizontally towards the farther side. A 4.5-ft. stand-pipe, set into a loose elbow on the end of the 4-in. pipe connecting this No. 1 tank with its mate, No. 2, was arranged so that it could be lowered, when necessary, in order to drain No. 1.

In this way No. 1 became full before it discharged into No. 2. On the end of the pipe discharging into No. 2 was put a T, and a 2-5-in. stand-pipe set in this reached above the top of No. 2. This brought the air to the surface without unduly stirring up the solution discharged into No. 2. In No. 2 were fitted at intervals three 2.5-in. rubber hose, 7 ft. long, attached to a wooden float that kept the intake about 2 in. under the top of the solution, whatever its level. In this way the solution was run to the zinc-boxes through 3-in. pipes. The bottoms of

these tanks were about 8 ft. above the floor of the precipitating-room; and the constant head in the pipes to the boxes averaged about 8 ft. With this arrangement the solution ran to the zinc-boxes comparatively clear, but not absolutely so, as it always was upon leaving the boxes. More or less fine slime was deposited on the zinc, which increased the amount of precipitates produced and gave these a reddish color after running through the filter-press.

Zinc-Boxes.—From the storage-tanks the gold solution was run to and through the zinc-boxes. The "first solution" charge was decanted at about 0.5 per cent. of KCy, and the "second," or "wash," at about 0.03 per cent. These were both pumped into the same storage-tanks, and contained, as mixed, between 3 and 4 grammes of gold and from 5 to 6 grammes of silver per metric ton (1000 liters); the average strength in KCy being between 0.03 and 0.05 per cent.

We had a set of 10 boxes and three barrels for holding the zinc. Of the boxes 7 were of sheet-iron; one of wood, with five compartments, each 12 by 16 in. and 19 in. deep; and two wooden boxes with four compartments, each 30 in. wide, 15 long and 15 deep.

The barrels were 2 ft. in diameter and 2 ft. deep, to the screen-bottom, and had 6 in. clear space between screen-bottom and the bottom of the tank. These three barrels, constituting one apparatus, were filled with zinc-shavings, about 6 cu. ft. in each, or 18 cu. ft. in the three.

The solution was delivered to the first of these barrels through a 1-in. pipe, directly in the center, running down to and discharging against the screen-bottom, which was of 0.25-in. mesh. It then came up through the zinc and discharged through a 1.5-in. pipe near the top, that ran over to and down into barrel No. 2, delivering the solution in the center and against the screen-bottom; then, rising through the zinc, discharged near the top through a 1.5-in. pipe into No. 3, where the operation was repeated; the solution discharging through a 1.5-in. pipe from near the top into the trough leading to the sump-tanks. These zinc-barrels were set about one foot apart, each about 8 in. lower than the next preceding, and so connected that any one could be cut out and cleaned while the others continued working. From 1.4 to 1.7 tons of solution per hour was run

through, giving, as a rule, almost perfect extraction. In fact, their work was just about as good as that done by the boxes.

Each of the large boxes held 15.6 cu. ft. of zinc, and passed about 1.1 tons of solution per hour. Each of the small boxes held 10.2 cu. ft. of zinc, and passed about 0.8 ton of solution per hour. These small boxes gave us the best general results and can be recommended as a standard.

Every 4 h. 0.5 kilo (about 1 lb.) of cyanide was put into the first compartment of each box. We considered that this was beneficial, as it tended to keep the zinc "sharp." The solution, after leaving the zinc-boxes, was conveyed to the two large sump-tanks under the floor, where it was made up into standard solution by the addition of the necessary cyanide; and this, as needed, was pumped up to the trough, to be mixed with the slimes for a new charge.

Whatever suspended matter the solution carried was precipitated in the zinc-boxes. We never found it any detriment to good precipitation, except that it required "clean-ups" to be more frequent than would have been necessary with a filtered solution. The slimes left in the zinc-boxes also augmented the volume of material to be smelted, and reduced somewhat its percentage of gold.

Each box (or barrel) was cleaned in turn, once a week; and, towards the last, the head-compartment of each was cleaned out every four days and charged with fresh zinc.

We turned the zinc on the premises, making the shavings as wide as possible, but using even the fine dust (of which there was but little), care being taken to feed it with the coarser shavings as well intermixed as possible. The consumption of zinc for the whole run of 11 months averaged about 0.9 lb. per ton of slimes treated. We discovered that good precipitation did not depend so much on the size as on the freshness of the zinc-shavings. In fact, we now judge that the finer the shavings the better, but this point may be contested. That, in order to secure a perfect precipitation, the zinc used must be freshly turned, there can be little doubt. As already observed, the zinc was turned on the premises. After a while, there came to be nearly a month's supply of zinc-shavings on hand. That used daily was naturally taken from the top, and consequently was nearly always freshly turned. Every precaution being

taken to secure good results, the average precipitation for the first six months was over 95 per cent. About the end of February the supply of zinc disks then on hand had been turned into shavings, and we began to use up the surplus pile. Within a week we had trouble with the zinc-boxes, the precipitation going, at times, as low as 81 per cent. Everything was done that could be thought of to remedy the evil, but it still continued. We noticed, however, that the box that was last charged with zinc did the worst work for that day. Towards the end of the month, judging from the irregular results from all the boxes, some good and some exceedingly bad, we decided that the trouble must be in the zinc. The turned zinc on hand lasted just through the month, and the average precipitation for that month (March) was only 93.59; whereas, for the preceding month it had been 97.70 per cent. The next month, starting on a new lot of zinc disks, we took care to turn only just fast enough, so as never to have on hand more than a day's supply of shavings in advance, and always to use, of those on hand, the first and not the last turned. From the outset, the precipitation in the zinc-boxes was all that could be desired, and the average precipitation for the month was 99.22 per cent. Samples of the solution were taken from heads and tails every hour; and for the assay samples 400 grammes (about 13 assay-tons) of each were evaporated, with a little litharge, on an enclosed sand-bed, heated by steam.

It would seem from this experience that, for perfect work in the zinc-boxes, freshly turned zinc is a desideratum. After a few days' exposure of the zinc-shavings to the atmosphere an imperceptible film of oxide forms; and, although bright and fresh to the eye, offers resistance to the action of the solution. This is undoubtedly remedied by the use of lead acetate, advocated by some operators; and this slight oxidation is, undoubtedly, the cause of the need of the acetate. We had no trouble in getting a precipitation of 98 per cent., when using freshly turned zinc, from solutions running as low as 0.01 and 0.02 per cent. KCy, and carrying some suspended matter in the shape of impalpable slimes.

In cleaning out a box, all the zinc was washed on a 0.25-in. mesh-screen over a 30-mesh screen, and all the zinc remaining on the coarse screen was returned to the boxes, new zinc being added to complete the charge.

The fine zinc and slimes that went through the 30-mesh screen were run through the filter-press and stored away, ready for smelting.

The coarser, which remained on the 30-mesh screen, was treated in specially prepared barrels, with dilute sulphuric acid, washed, and also stored to await smelting.

VI. Reduction of the Precipitates to Bullion.

The product yielded by the zinc-boxes was of rather low grade, very seldom assaying over 3.25 per cent. in gold and 4.50 per cent. in silver; but it carried from 7 to 15 per cent. of copper. The fine zinc, before it was removed from the 30-mesh screen, was thoroughly washed, and had the usual black color, whereas the pressed precipitates were red, and, at the first, had the same muddy consistency as the material of the tailings-dump.

Acid Treatment.—When we started the slimes treatment, precipitates and zinc were treated with dilute sulphuric acid in 2 by 3 ft. wooden barrels, 2 parts of precipitates being mixed with 1 part of zinc.

It was found, however, cheaper and more convenient to treat the zinc by itself with dilute acid (2 parts of water to 1 of concentrated acid). After ebullition had ceased the barrels were filled with water, and the material was washed for 6 days.

It was also noted that the use of hot water was more satisfactory than that of cold.

The following are two analyses of the material as smelted. Analysis I. represents the mixture when precipitates and zinc were being treated with acid. In No. II., only the zinc had been treated with acid.

Analyses of Mixed Precipitates and Zinc, and of Zinc Alone.

	I. Per cent.	II. Per cent.
Au,	3.395	2.288
Ag,	4.981	2.8955
Cu,	6.955	12.15
Zn,	16.148	20.15
Fe_2O_3,	0.094	2.15
Al_2O_3,	7.426	8.45
$CaSO_4$,	28.32	26.86
SO_3,	1.523	0.955

As has been shown, these precipitates were rather too low in grade to be smelted on the premises, especially as there were no facilities for smelting on a large scale, and also in view of the large amount of flux needed. However, constant unsatisfactory differences—as high as 5 per cent., at times—in the returns from the smelting company led us to decide upon reducing the precipitates to bullion from the plant.

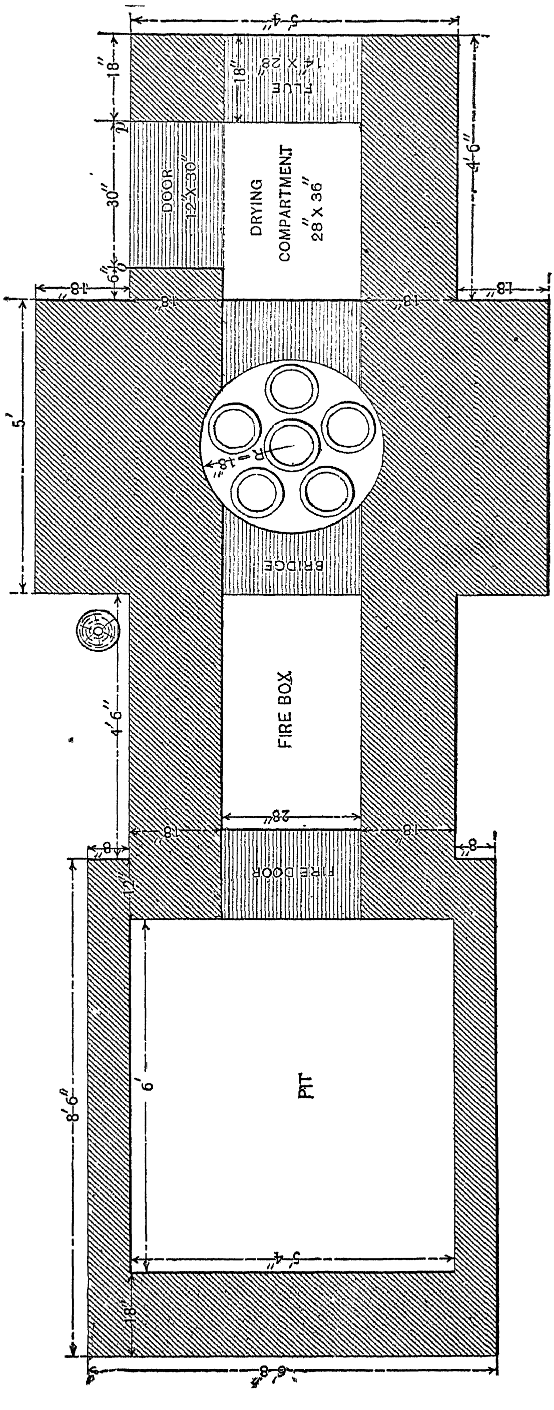
The furnace used for smelting was built on the principle of the bullion pot furnace, but to hold 6 crucibles, and to be fired with wood instead of charcoal, which was the available fuel for assaying and melting bars. Figs. 5 to 8, inclusive, show the details of the construction of the furnace.

The fire-box of the one we built was somewhat out of proportion to the rest of the furnace, but as old materials were used for the construction, it did not seem advisable to spend much time in alterations. The front of the furnace was an old boiler-front that was lying around, and the grate-bars were the same as were used in one of the 60-H.P. boilers that ran the stamp-mill. Notwithstanding the apparently excessive size of the fire-box, the furnace did not use a large amount of wood, and heated up rapidly and well. In melting copper, all that was necessary was to carry a heavier fire, and it did not take very long to melt 60 kilos of copper in a No. 50 crucible. In melting precipitates, the average daily consumption of wood was 0.6 cord.

When melting was started, considerable trouble was caused on account of the crucibles being eaten through, sometimes not lasting more than one day; and it was noticed that just the top of the slag would have the corrosive action, eating a ring about 0.75 in. wide through the crucible. This top layer of slag was found to be white, with a disagreeable taste; and a few qualitative tests showed it to be apparently a mixture of calcium and alkaline sulphates. The addition of some hematite iron-ore, which happened to be on hand, was tried and improved matters considerably, having a much more beneficial effect than the addition of pieces of scrap-iron.

After long trials, the charge for smelting was finally fixed at the following mixture, in kilogrammes: 100 precipitates; 34 borax; 24 sodium bicarbonate; 5 sand; 6 clay; 3 ashes, and 5 hematite.

Fig. 5.



Plan of Furnace for Smelting Gold, Silver, Copper and Aurocyanides, with Wood as Fuel.

The crucibles would be filled in the morning and refilled, as the previous charge melted down, until in the afternoon they were finally full. In this manner 120 kg. of precipitates would be melted in from 10 to 12 hours, depending on the heat of the furnace.

The daily products were bullion, matte and rich slag.

Each crucible yielded a disk of bullion weighing from 1 to 2 kg. When enough had accumulated, these disks were re-melted and cast into bars, which assayed about .300 fine in gold and about .330 in silver, the balance being made up of copper, iron and zinc.

The matte yielded by each crucible-charge weighed about 2.5 kg. This matte was remelted at the end of each month with an excess of scrap-iron. Each crucible, nearly full of molten matte, would yield from 15 to 20 kg. of bullion, in which, however, the silver was much in excess of the gold. No separate assay, however, was made, as this bullion was always mixed in with the other bullion. The final matte thus obtained was rich in copper, iron and silver, but carried very little gold. The matte ready for shipment assayed 20 grammes of gold and 84,400 of silver per metric ton.

The slag obtained from smelting was rich, running from $500 to $600 per metric ton. This slag, as it accumulated, was run over a lead bath in a Mexican *vaso*, which extracted between 92 and 95 per cent. The waste slag from this *vaso* was not treated further, as the values were too low to warrant running it over again; although, by such additional treatment, it could have been brought down to $2 or $3 per metric ton.

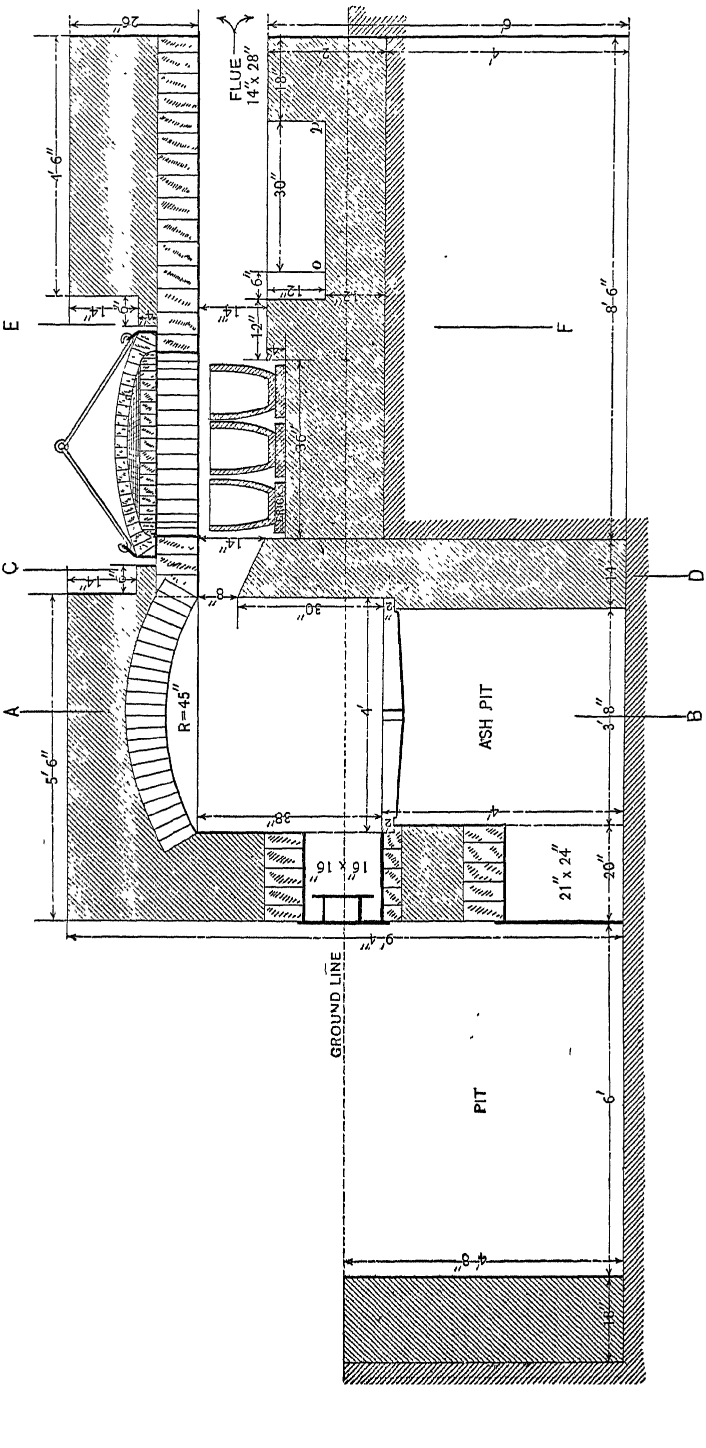
VII. Conclusions.

From what has been written, it will be seen that we successfully treated a material that offered every incentive to let it alone, had it not been for the high gold-values it contained.

A good idea of the physical character of the slimes was given by our experience as to the effect of floods upon them. Before the first flood, a rock falling anywhere on the surface of the dump would splash mud in all directions. A hog, running at full speed, jumped over the ridge, at the upper edge, one day, and went out of sight, never to appear again.

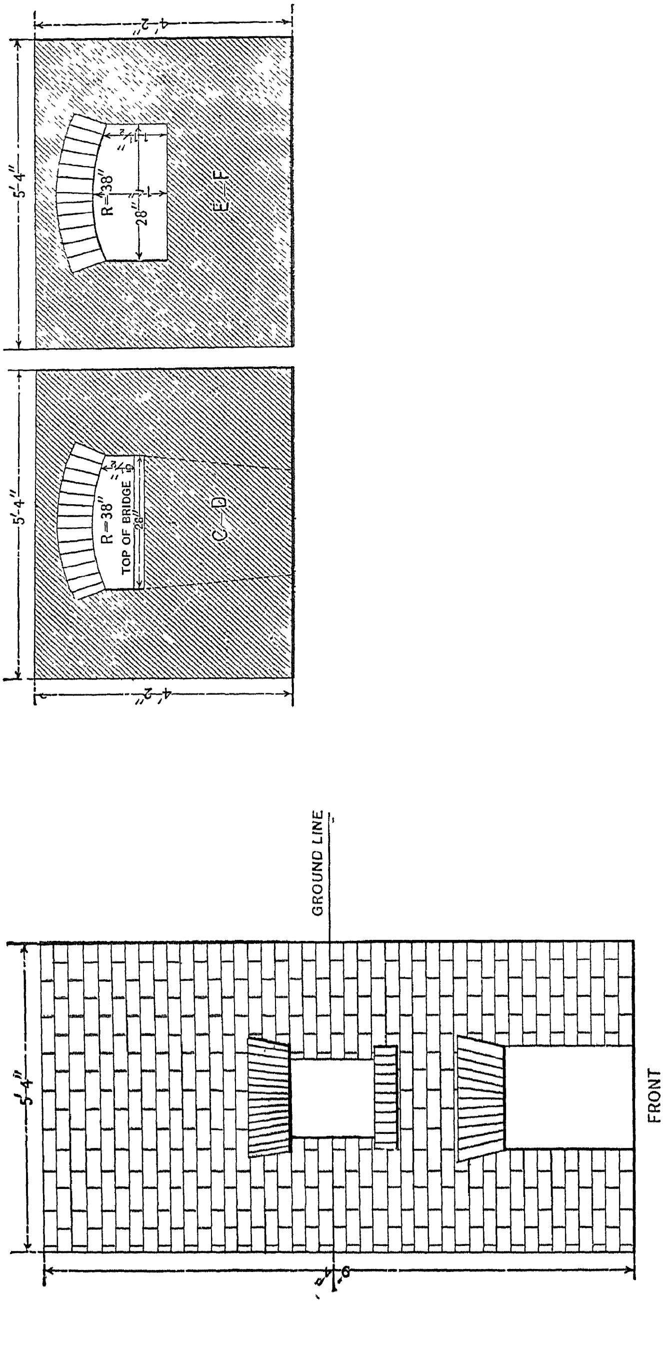
Yet while any weight would sink down through the jelly-like mass, it was of such consistency that it would stand in

Fig. 6.



Smelting-Furnace. Vertical Longitudinal Section through Fig. 5.

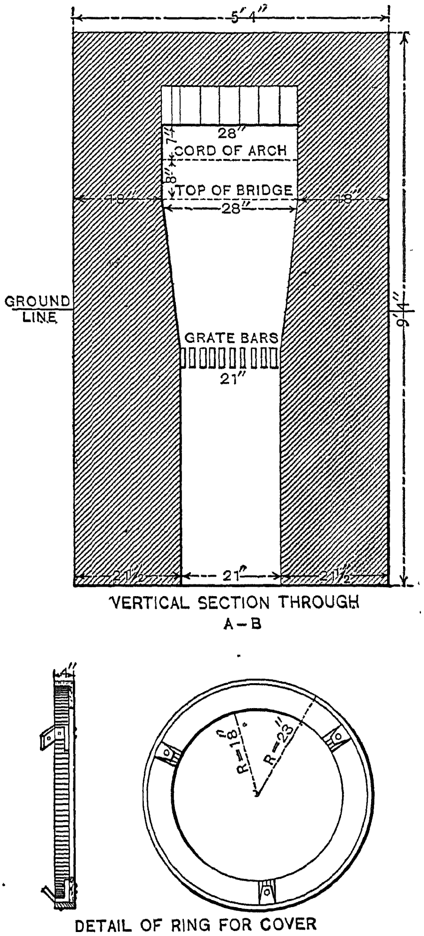
Fig. 7.



Smelting-Furnace. Front Elevation and Vertical Sections through C-D and E-F, Fig 6.

banks 8 ft. high at an angle of 80°. When the first flood came, it went over the dam 4 ft. deep and 50 ft. wide, and in a few minutes carried away the earthy and rocky portions. This large volume of water rolled over the face of the slimes and, in the two hours it lasted at full force, did not cut it back 10 ft.

FIG. 8.



Details of Smelting-Furnace. (See Figs. 5 and 6.)

The next morning there was an excavation at the foot of the dump cut 6 ft. deep and 20 ft. across, down into the bed of the creek, in solid gravel, many of the boulders washed out weighing as much as 50 lbs. A rock thrown with ordinary force against the face of the dump would sink in at least a foot. A

man standing out on it would have sunk through to the bottom. Out back from the edge, where a stream was going over the face in a volume 10 ft. wide and a foot deep, a rock alighting would splash mud and sink out of sight; yet the water could not cut the face back 5 ft. a day. At the next flood an immense volume rolled over the face to a depth of at least 4 ft., and, to all appearances, the face might as well have been solid rock; the water seemed to make no impression on it whatever.

After over a month, a steady stream and four floods had made hardly any further impression on the body of the dump. The small constant stream seemed to have greater effect than a flood; for in the month's time it had gradually carried back a cut some 8 ft. wide, down to the creek-bed, for about 200 ft.

The cost of treatment per ton was about $5 gold, divided as follows:

		Per cent.
Cyanide, 7.31 lbs.,	$2.05	40
Zinc, 0.93 lbs.,	0.18	4
Administration and Labor,	0.99	20
Royalty,	0.50	10
All other expenses: Materials, Bullion, Insurance, etc.,	1.26	26
	$4.98	100

Under materials are included wood, acid, and other supplies used in improvements and repairs. Of the last item, the bullion costs constituted about one-half, or 13 per cent. of the total costs, made up of 8 per cent. for reduction expenses and 5 per cent. for freights, duties and commissions. Royalty was another heavy extra expense, being 5 per cent. on the gross output.

Our total expense of $5 per ton compares very favorably with the average cost of the treatment of the sands by percolation, which was $7 per ton.

We believe that, under like conditions, such as distance from the coast, the necessity of bringing in everything on mule-back, etc., no better can be done anywhere in Mexico. The only possible further reduction in cost would be in the consumption of cyanide, and that would depend wholly on the chemical and mineral character of the ore. We could have worked to better advantage had the plant been built for the work, instead of being an old plant altered and adapted, as far as possible, to the new requirements. Three working-sheets are appended of charges at the beginning of treatment, near the middle and near the end. From these can be gained a good idea of our

system, time of treatment, value of slimes, and general results. It will be noticed that gradually the amount of solution charged was increased; the amount of slimes charged was decreased, and the amount of solution decanted, in proportion to that charged, steadily decreased—notably so towards the end.

It was due to these changes alone that we were enabled to keep up the good extraction to the end.

APPENDIX.

The following specimens will show the nature of the observations and records made in our regular practice.

Cyanide Department, Anglo-Mexican Mining Company, Limited, San José de Gracia Plant.

Record of Treatment of Charge No. 160, *Tank No.* 3, *Sept.* 26, 1900.

Date.	Time.	Hours.	Strength of Solution.	Remarks.
Sept.	A.M.	H. M.	Per cent.	
26th......	8.05			Commenced charging.
	9.10	1 05		Charged.
			0.23	Solution charged, 25,395 liters (25.395 M. tons).
	P.M. 12.35	4 30	.08	Lime added, 50 lbs.
	1.05	5 00	.09	Agitation stopped.
				Settled 7 hours.
	8.05	12 00		Decanting started.
	9.25	13 20	.11*	Decanted 22½ in. 17,775 liters.
				Water added, 18,170 liters.
	9.40	13 35		Lime added, 25 lbs.
	10.25	14 20	.08	Agitation stopped.
				Settled 6 hours.
27th......	A.M. 4.25	20 20		Decanting started.
			.08	Decanted 21½ in. 16,985 liters.
	6.00	21 55		Water added and charge agitated.
	6.35	22 30		Started discharging.
	7.05	23 00		Discharged.
	Total.....	23 00		

	Au. Per ct.	Ag. Per ct.
Total extraction, .	86.91	68.51
With solution, . .	81.31	64.09
Actual extraction, .	77.98	61.21

	Grams Au.	Grams Ag.
Heads, ...	21.40	36.20
Tails, washed, ...	2.80	11.40
Tails, unwashed, ...	4.00	13.00

	Grams.
Soluble gold, ...	1.20
" silver, ...	1.60

Moisture, 22.2 per cent.
Metric tons, wet, 12.626.
Metric tons, dry, 9.823.
Avoirdupois tons, dry, 10.80.

	Au. Per ct.	Ag. Per ct.
Solution extraction,† . . .	95.9	95.5

KCy consumed per ton, 5.8 lbs.

* Effects of lime.

† Zinc-boxes.

Record of Treatment of Charge No. 832, *Tank No.* 3, *Jan.* 26, 1901.

Date.	Time.	Hours.	Strength of Solution.	Remarks.
Jan.	A.M.	H. M.	Per cent.	
26th......	8.00			Commenced charging.
	8.50	50		Charged.
			0.20	Solution charged, 27,200 liters (27.2 M. tons).
	P.M. 12.30	4 30	.08	Lime added, 50 lbs.
	1.00	5 00	.11*	Agitation stopped.
				Settled 7 hours.
	8.00	12 00		Decanting started.
	9.20	13 20	.12	Decanted 24 in. 17,352 liters.
			.15	2d solution added 17,352 liters.
	9.35	13 35	.13	Lime added, 25 lbs.
	10.20	14 20		Agitation stopped.
	A.M.			Settled 6 hours.
27th......	4.20	20 20		Decanting started.
			.13	Decanted 23 in.
	5.40	21 40		Water added and charge agitated.
	5.55	21 55		Started discharging.
	6.25	22 25		Discharged.
	6.35	22 35		Cleaned.
	Total.....	22 35		

	Au. Per ct.	Ag. Per ct.
Total extraction, .	81.57	71.50
With solution, . .	75.00	65.30
Actual extraction, .	73.86	63.02

	Grams Au.	Grams Ag.
Heads, ...	19.00	36.00
Tails, washed, ...	3.50	10.25
Tails, unwashed, . . .	4.75	12.50

	Grams.
Soluble gold, ...	1.25
" silver, ...	2.25

Moisture, 16 per cent.
Metric tons, wet, 11.129.
Metric tons, dry, 9.348.
Avoirdupois tons, dry, 10.283.

KCy consumed per ton, 8.14 lbs.

	Au. Per ct.	Ag. Per ct.
Solution extraction,† . .	98.48	96.51

* Effects of lime.

† Zinc-boxes.

Record of Treatment of Charge No. 1695, *Tank No.* 3, *June* 26, 1901.

Date.	Time.	Hours.	Strength of Solution	Remarks.
June.	A.M.	H. M.	Per cent	
26th	8.00			Commenced charging.
	9.00	1 00		Charged.
			0.15	Solution charged, 29,160 liters (29.16 M. tons).
	P.M. 12.30	4 30	.06	Lime added, 50 lbs.
	1.00	5 00	.09*	Agitation stopped.
	8.00	12 00	.10	{ Settled 7 hours. Decanting started.
	9.20	13 20		Decanted 19 in., 13,737 liters. Water added, 13,737 liters. Lime added, 25 lbs.
	10.20	14 20	.05	Agitation stopped.
27th	A.M. 4.20	20 20		{ Settled 6 hours. Decanting started.
	5.40	21 40	.055	Decanted 18½ in., 13,375 liters. Water added and charge agitated.
	5.55	21 55		Started discharging.
	6.25	22 25		Discharged.
	6.35	22 35		Cleaned.
	Total.....	22 35		

	Au. Per ct.	Ag. Per ct.
Total extraction, .	84.29	58.56
With solution, . .	77.14	48.64
Actual extraction, .	75.73	46.40

	Grams Au.	Grams Ag.
Heads, ...	17.50	40.30
Tails, washed, ...	2.75	16.70
Tails, unwashed, . . .	4.00	20.70

	Grams.
Soluble gold, ...	1.25
" silver, ...	4.00

Moisture, 15.8 per cent.
Metric tons, wet, 9.896.
Metric tons, dry, 8.332.
Avoirdupois tons, dry, 9.166.

	Au. Per ct.	Ag. Per ct.
Solution extraction,† . .	97.39	95.40

KCy consumed per ton, 7.20 lbs.

* Effects of lime.

† Zinc-boxes.

Notes on the Mines and Minerals of Guanajuato, Mexico.

BY WILLIAM P. BLAKE, TUCSON, ARIZONA.

(Mexican Meeting, November, 1901.)

INTRODUCTION.

THE ancient city of Guanajuato, the capital of the State of that name, has been built up and sustained chiefly by the mining industry based upon the veins of the Veta Madre and La Luz. It is distant about twelve hours, by rail, from the City of Mexico. Its elevation above the sea is about 6300 ft., and it has a salubrious climate. The population, at the date of my visit in 1891, was estimated at from 80,000 to 100,000 persons. The place is justly celebrated for the antiquity, depth and extent of the mines, the magnitude of the deep shafts, and the enormous total yield of the district in silver and gold, which is comparable with that of the Comstock Lode in the United States.

Several important public institutions are located at this center. The State office for the records of claims and of the statistics of mining and production is known as the *Deputacion de Mineria.* The Mining College, with its fine collection of ores and minerals from the mines of the region, is highly interesting to mineralogists. A mint for the coinage of silver, but not of gold, coins from four to twelve millions of silver dollars annually. The silver received at the mint is melted in an open-hearth furnace, and is ladled out and cast into long and thin bars, which are rolled down to the proper thickness for the blanks. The bars contain some gold which is not parted. There is an export of doré bars to Germany, amounting in value to from $1,000,000 to $1,500,000 annually. There were, in 1891, upwards of forty reduction-works in and about the city where the silver ores were treated, chiefly by the ancient *patio* method. In these works were 65 Chilean mills, 301 arrastres of large size, and 936 of smaller dimensions. There were 36 steam engines, but mule-power was generally used at the ar-

rastres, precisely as shown by Ward and others in 1825–27. In the Hacienda de Flores alone there were 40 arrastres, with from two to four mules each.

The transportation of the ore from the mines to the reduction-works is effected wholly upon the backs of mules. Long trains of mules, heavily laden with ore in raw-hide sacks, are common daily sights in the streets of Guanajuato and upon the roads leading to the town.

In 1891, at all of the mines about Guanajuato, the high-grade ores, such as yield by assay 20 marks to the arroba and upward —say 100 ounces and over to the ton—were carefully selected out, sacked, and shipped to smelting-works either in the United States or in Europe. The milling-ores which would not pay to ship were sent, as above, to the city, where they were sold by auction to the highest bidder and were taken to the *haciendas* for treatment.

The history of mining in Guanajuato dates practically from the Conquest. How long before that date silver had been extracted from the upper portions of the veins by the Chichimecas and other aboriginal tribes will probably never be known. The production from the Veta Madre, or "Mother Vein," from 1766 to the time of Humboldt's visit, with the production from 1804 to 1825 added by Ward, amounted to $225,935,736 in value.

Vein-Systems.

There are three recognized vein-systems: the Sierra, the Veta Madre, and the La Luz. The two latter have been the chief producers.

The general direction or strike of the veins is NW. and SE. There are numerous cross-veins and branches, believed to follow in a general way the cleavage-planes of the rocks.

The Veta Madre System.

The first shafts were commenced at Mellado and Rayas, in 1558. Historical details of the progress of mining are given by Humboldt, Ward, Alaman, Tilmann and others. Ward, in reviewing the subject, writes in regard to the Valenciana mine upon the Veta Madre, that, after being slightly worked towards the end of the 16th century, it was neglected until the year 1760. In 1768 the mine had attained the depth of eighty meters

and began to produce enormously. From 1788 to 1816 the production averaged in value $1,383,195 per annum.

At the date of Ward's visit (1827), the principal mines were the Valenciana, Mellado, San Juan de Rayas, Secho, Cata and Santa Anita. At that time several shafts had been sunk—the Tiro Viejo de San Antonio; Tiro de Burgos; the hexagon shaft of Nuestra Señora de Guadalupe; and, finally, the great octagonal shaft called El Tiro General, commenced in 1801 and carried on until the beginning of the Revolution, when it had reached the depth of 635 Mexican varas.

This great main shaft upon the Veta Madre is one of the mining wonders of the world. It is eleven varas in diameter and 537 meters deep. To the depth of 100 meters it is lined with masonry; for the remainder of the distance the rocks are firm, and do not require timbering or masonry.

To those who have not visited this or other of the great mining-shafts of Mexico, the reason for their large dimensions is not at first apparent. This reason is, that many *malacates* or horse-whims may be worked simultaneously and independently around the opening. Around an octagonal shaft eight or more whims can be located, or they may be replaced by hoisting-engines. At the time of my visit in 1891, three 25-H.P. steam-hoists were in operation, and one 60-H.P. engine. Platform-cages were guided by wire-rope cables, stretched vertically from the top to the bottom of the shaft. The great cylindrical steel water-barrels were similarly guided. Two hundred and twenty-four barrels of water were raised in twenty-four hours.

The vein is described as in three distinct parts, separated by country-rock or *tepetate*, and named *blanco* (24 meters); *verde* (15 meters), and *negros* (10 meters). Including the barren intervals, the aggregate width of the vein is 125 meters.

The white (*blanco*) ores shown me consisted chiefly of quartz with disseminated silver sulphide; the black ores (*negros*) contained much iron pyrites, sometimes carrying argentite in small particles, and distinct crystals of argentite from the bottom of the shaft.

La Cata.—A side-trail from the city winds downwards amongst the vast attle-heaps of La Cata, under ancient castellated walls, and towers like those of mediæval castles, past churches with domes and spires, nestled in the ravines, with

picturesque villages here and there. The large heaps of refuse rock, neatly piled up and walled in, are composed chiefly of black slate, with reticulations and veinlets of white quartz in all directions. It would appear that the *La Cata* workings must have partaken of the nature and form of *Stockwerks*.

Rayas.—The largest engine seen was at Rayas. It was rated at 150 H.P., and was built at the Union Iron Works, San Francisco. It was hoisting water in buckets from a depth of 500 varas, 3 tons at a lift, 2 yards per second; wood being used for fuel. Coal, from Chihuahua, costs $22 per ton, but is not so good as the coal from New Mexico, which costs $20 by rail to Marfil. There is no large pump on the lode.

The main shaft here is octagonal, and is even larger than the shaft at the Valenciana, being, according to Ward, two and a half varas greater in diameter. The dimensions stated to me in 1891 were: diameter, 12 meters; depth, 400 meters. It was then filling with water in the lower portion. The depth in 1827 was 450 varas. Ward also cites the fact that one of the *malacates* at that time was the largest ever built in America, the winding-drum being 8.5 varas in diameter, and the beam 24 varas in length. It was worked by 8 horses, changed every three hours.

The La Luz System.

In going about 5 miles southward from Guanajuato, to La Luz, the following mines are passed in succession:

San Bernabe, San José de los Muchachos, El Refugio, La Trinidad, Jesus Maria, Santo Nino, San Pedro, Melladito, La Luz, Santa Clara, San Vicente, Los Locos, Sangre de Cristo, La Purissima, St. Nicholas, Bolanitos.

Shafts and dump-piles of waste and ore show the wide extent of the underground work, and the great activity of mining in the past; but at the time of my visit in 1891 very little work was in progress, and that chiefly for the purpose of holding the claims under the law; the proprietors hoping for some development or deep tunnel for drainage of the lower levels, then flooded with water. Bolanitos and Melladito, a short distance east of the town, and the vein of La Luz, were producing largely, and also La Purissima; the water being kept out by hoisting it in the primitive Mexican fashion with large sacks of raw-hide.

The aggregate product of this La Luz series of mines appears to have been considerably over $300,000,000 in value, exclusive of the San Bernabe, known to have been a large producer. The following tabular statement was officially prepared to accompany a map and section of the mines of the district, shown at Paris in 1889:

Mines.	Opened.	Depth. Meters.	Working-Depth Meters	Known Product. (Value.)
San Bernabe	1548	......	175	....
La Luz	1840	400	175	$140,000,000
San José	......	320	175	20,000,000
Santa Clara	1850	260	175	17,000,000
Refugio	1851	290	196	23,000,000
San Vicente	1853	286	210	27,000,000
La Trinidad	1861	200	180	6,000,000
Los Locos	1863	238	180	860,000
Jesus Maria	1858	310	240	16,000,000
Villarino	1850	210	105	3,000,000
El Santo Nino	1858	200	100	9,000,000
La Purissima	1852	350	350	25,000,000
San Pedro	1860	290	350	14,000,000
San Nicolas	1860	265	265	12,000,000

In 1889 the annual yield was officially reported to be 17,700 tons of silver-ore, from which 24,000 kilogrammes of silver and 90 kilogrammes of gold were extracted. This would correspond to 576,000 oz. of silver and 2160 oz. of gold, the total value of which would be about $619,200. The average value of the ores according to these figures was about $35 per ton.

The general direction of the La Luz vein is about N. 55°–60° W., and S. 55°–60° E., but it cannot be definitely traced beyond the El Carmen opening, where the vein is believed to cross the La Luz branch of the San Bernabe river. There are several intersecting veins. By some, the vein, here called La Luz, is called the Plateros. Prof. P. Aguilar regards the intersecting veins as probably following the cleavage-planes of the clay-slate country-rock.

The chief vein-stone or gangue of these veins is a compact white quartz, with some calcite carrying argentite, pyrargyrite, stephanite, polybasite, miargyrite, and sometimes a little cinnabar. There is a considerable amount of finely disseminated iron pyrites, and there are small quantities of galenite. At Bolanitos the chief silver-mineral is the simple sulphide of silver (argentite).

The choicest crystallized silver-minerals now in the public and private collections in Mexico were supplied from the mines of the La Luz system. One mass of very fine crystals of silver-ore, in the State collection of Guanajuato, weighs several pounds and is without gangue. A fine mass of ruby silver-ore, weighing 25 lbs., was sent to the City of Mexico by Maximilian. The Refugio mine has yielded some of the most beautiful pink and white apophyllite crystals ever seen.

The width of the lode in the workings upon La Luz is variable. It is reported as from 4 to 20 meters. In one place in the San Miguel, a portion of the vein has been broken up and re-cemented, forming a brecciated mass.

At the mines of the La Luz system, from one end of the line to the other, there are large heaps of second-class ore and refuse rock. These heaps are mines of wealth to the poor people. Men, women and children are constantly at work digging over these piles, and gleaning from them small quantities of ore, a few ounces or pounds, which they are allowed to take away and sell by paying a small sum daily for the privilege of working on the ground. At the La Luz, where a large portion of the refuse-heap has been washed away by the rush of waters, and spread along the channel of the creek for a mile or more, there were at the time of my visit many groups of men and women diligently seeking for bits of vein-stone, out of which they might break a few grains of salable ore.

Persons familiar with the La Luz mines (including the very competent authority, Ignacio Olmeda, who has been connected with them since the opening of the great bonanzas in 1840), concur in the opinion that there are now large quantities of second-class ore left behind in the mines, that would not pay to extract, send to Guanajuato and reduce by the *patio* process, but would pay a good profit if they could be milled near the mines by modern methods, being estimated to be worth not less than four marks of silver per *monton*, equivalent to 32 oz. per 3200 lbs., or 20 oz. per ton. Owing to the absence of water, the ores cannot be worked at the mouths of the mines.

Bolanitos Mine.—In 1891 the Bolanitos was in *bonanza*, and was actively worked by Sr. Don Andrade, of the City of Mexico. It is less than a mile, in a straight line, from La Luz. It was an abandoned mine as late as 1883, when it was reopened and worked with great success and profit, having produced in seven

years not less than $3,000,000. Modern machinery and methods are used. The main shaft is 20 ft. in diameter, and has steam-hoists on opposite sides.

The Victoria Tunnel.—The project of this name was based on concessions from the Mexican government prior to the year 1901. It contemplated a large drainage-tunnel, affording also ventilation and transportation for the whole series of mines of the La Luz system. It was to be 1800 meters in length from the mouth of the tunnel on the San Bernabe river or creek to the La Luz mine, which it would cut at a depth of about 300 meters. The lower levels of all the mines are flooded with water. The drain-tunnel would drain off some 300 ft. of this water, and give access to a large amount of unexplored ground. It is projected to run on a straight line from the cañon of San Bernabe to the bottom of the Arcangel shaft at a depth of 300 meters from the collar. A tunnel called the San Bernabe drains the La Luz to a depth of about 650 ft.

The Rock-Formations.

The rock-formations from La Luz to San Bernabe cañon are metamorphic clay-slates, quartzites and conglomerates. In some places the rocks are dioritic, either from metamorphism or by reason of the intrusion of dikes. All the formations are uplifted, and are flexed and contorted, so that the dip is variable. There is abundant evidence of pyritic mineralization, the rocks being everywhere rusty and red at the surface.

The Minerals of Guanajuato.

There is a fairly complete representation of the ores and minerals of the district in the Museum of the School of Mines, in the several private collections at the larger haciendas, and in the homes of the leading mining engineers.

Ruby-Silver (Pyrargyrite or Proustite).—A mass of ore, referred to as "ruby-silver," was sent from the La Luz vein by Maximilian to the City of Mexico, and is stated to have weighed 25 lbs. I saw in the museum fine crystals of pyrargyrite an inch long.

Argentite.—Perfectly formed crystals of large size are in the State and private collections.

Aguilarite, a sulpho-selenide of silver, occurs here in skeleton dodecahedral crystals in the San Carlos mine, but is very rare.

It was described by the late Dr. F. A. Genth in the *Amer. Jour. Sci.*, 41, 401 (1891), and was named in honor of Prof. Ponciano Aguilar, of Guanajuato.

Stephanite, *Polybasite*, *Miargyrite* and *Cinnabar*, also occur in the mines.

Apophyllite.—Large, finely formed crystals, white and rose-colored, from El Refugio.

Calcite.—Brilliant, highly modified crystals, and twin crystals of great beauty.

Map and Section.

In 1883 the Mexican government appointed a commission of engineers to prepare a profile-section and a map of the mines upon the Veta Madre and the La Luz vein, for exhibition at New Orleans in 1883, and again at Paris in 1889. This special commission was formed by the appointment of the eminent mining engineers Srs. Francisco Glennie, Ignacio G. Rocha, Ignacio Ibarguengoitia, Juan N. Contreras and Ponciano Aguilar, all officially identified with mining in that region. The immediate and detailed work of compilation and drawing was entrusted to Prof. Aguilar, who was aided by the engineers of the various mines, and by the official records and maps of the workings on each of the different properties. The section is beautifully drawn and colored. It is nearly 30 ft. long, and cost the State of Guanajuato more than $3000.

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The Mining District of Pachuca, Mexico.

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(Mexican Meeting, November, 1901.)

I. General Description.

The two mining districts of Pachuca and Real del Monte, well known for their antiquity and the extraordinary richness of their veins, are situated, 3 miles apart, only 62 miles north of the City of Mexico—the first being on the western, and the second on the eastern slope of the Pachuca range of mountains which bounds the great valley of Mexico.

Close to the celebrated mining region of Pachuca is located the city of the same name, capital of the State of Hidalgo, at 2460 meters above sea-level and 20° 07′ 35″ North latitude, with 35,000 inhabitants, the majority of whom work in the mines; the remainder being Government employees, merchants, and a small number engaged in less important industries.

The city extends along both sides of the cañada which carries the waters of the river called "Avenidas de Pachuca," the banks of which are united by four bridges at regular intervals.

The attention of the traveler approaching the city is first attracted by the appearance of the mountains, barren of vegetation, bounding the city with rocky cliffs and steep declivities, the grades of which serve as foundations to the irregular and varied groups of houses. Above these are the dumps, and, close by them, the mouths of the shafts, covered with conical tile roofs. The smoke of the chimneys, the noise of the mills and the appearance of some of the constructions reveal at first glance the industrial character of the place. At the left of the entrance to the cañada, the mountain of San Cristóbal, celebrated for the famous vein of Xacal, one of the richest and earliest exploited in the district, rises 450 meters above the city.

Pachuca possesses a Scientific Institute, where students, mostly natives of this State, receive a technical education as mining engineers, topographers, assayers and refiners. (Diplomas were formerly given in law also.) This Institute is also provided with a cabinet of philosophical instruments, a chemical laboratory, a library, a meteorological observatory and a small museum of natural history furnished with collections of minerals for the use of the students. The spacious building is located on the slopes of San Cristóbal mountain, and was formerly a Catholic church and convent.

For years the practical Mining School has been established at Pachuca, where the students from the Engineers' School of the City of Mexico (formerly called School of Mines) have acquired practical and professional training. Most Mexican mining engineers of the present generation have been trained at Pachuca, more on account of the great variety of machinery in the several mines and milling plants located there, than the conveniences offered by the school.

The city contains some other important buildings, erected in the midst of the humble and monotonous construction of houses hurriedly built, when mining prosperity was at its zenith, to satisfy the urgent necessities of the rapid increase of population. Some of the large edifices are worthy of mention. For instance, the Safes and Real del Monte and Pachuca Co.'s manager's office, an old Spanish structure, erected in 1670 by the Marquis of Mancera to encourage mining, for it was both a quicksilver-market, to supply miners at reasonable prices, and a place for keeping funds for buying ores as well as for paying taxes to the Crown.

The topographical conditions of the town-site explain the lack of regularity in the structure of the houses as well as the laying out of streets and avenues. The city is traversed by three main avenues, intersected by cross streets, the majority of which are treacherous narrow paths leading up the hillsides.

The Government Palace is remarkable for its solid construction, uniformity and good proportions of its façade. The modern structures in different portions of the city bear a more grand and elegant style. Among these the Santa Gertrudis Mining Co.'s offices deserve special mention; also Grenfield's

hotel, where visitors can find comforts of all kinds, which is situated in front of a square and on the same spot where the stage-coach depot used to be; also the manager's office of the San Rafael Co. and the *Red House*, occupied at present by the Justice Court. The last-named building was erected at the end of the 18th century by Count Regla, to furnish work for the poor starving people. It has been greatly improved since. The city also has two Catholic and two Methodist churches, the latter usually attended by North Americans, and by English miners, mining carpenters and mechanics, most of them from the County of Cornwall.

There are also two public gardens; a statue erected to the memory of the parish priest Hidalgo, first leader of Mexico's independence, from whom the State of Hidalgo takes its name; a theater, recently constructed, which shows a handsome façade; and some private residences of recent construction. In the outskirts and within the boundaries of the city may be seen the mills where the ores extracted from the mines, especially those too low in grade to be profitably exported, are treated. In these days, the exportation of ores is very important. The principal mills in operation at present are those of Loreto, Purissima Chica and Progreso to the north of the city, and La Union, Cuervito and Guadalupe at the entrance of the city from the valley, and Bartolome de Medina.

During the busy hours of the day when the mines are being worked there is not much traffic in the streets, miners having to walk from four to six kilometers early in the morning to reach the mines, returning in the evening. There is an unusual degree of animation on Sundays, especially in the market squares, furnishing an opportunity to study the popular customs, which are very similar to those of all Mexican mining towns. Miners spend on Sundays, in buying provisions and enjoying their favorite amusements, such as bull fights, etc., the greater portion of the earnings of the week.

II. History.

The mining district of Pachuca has been known since the remote days of the Conquest. All historians fix as the date of its discovery the year 1522, scarcely two years after the Conquest of New Spain was consummated by Hernan Cortes.

Some persons are under the impression that the mines had already been exploited by the Aztecs before that time. There is no written testimony to prove this; and it may be that the excavations made by the Indians in the beautiful place called Las Navajas were supposed by early observers to be metal-mines. They were, in fact, quarries from which obsidian was extracted by the aborigines to manufacture the lance-points, knives and other utensils so much admired by historians, archæologists and ethnologists. These excavations, though now almost completely destroyed, can be recognized on the slopes of the mountains not very far from a town called Pachuquilla, which, according to Humboldt, was the first Catholic one settled by Spaniards in the *Intendencia de México.*

The etymology of the name of Pachuca is not well known. Father Baltazar de Medina derives it from the Indian word *Pachoa*, which means closeness or narrowness, in reference to the narrow ravine between mountains, which forms the entrance to the city.

It is impossible now to trace the exact history of the mining development of this district, because the city records and official documents kept in the convents were destroyed during the war of independence and other internal revolutions. It is only known that one of the veins first discovered and exploited was the Xacal, the outcrop of which projected from the slope of the cañada of Pachuca at a place where old open cuts and workings now give evidence of former operations.

After 1557 the mines of Pachuca won their celebrity through the impulse given to their exploitation by the fortunate invention, in that year, of the patio process for the reduction of ores, made by a miner named Bartolome de Medina. It is stated that this discovery took place where La Purissima Chica mill is now situated, near the San Juan mine at the terminal depot of the Pachuca street-car line and about seven minutes' ride from the city. As a consequence of that improvement the mines were worked more successfully during the XVIth and XVIIth centuries, with ups and downs occasioned sometimes by the monopoly of quicksilver achieved by the Crown of Castile.

In 1670 the Royal Safes were established, where quicksilver was sold. At this time the Xacal mine alone yielded $7000

per day, the Encino mine 240,000 ounces of silver per annum, and La Trinidad, during ten years and with a force of 1000 men, produced about $40,000,000.

In 1700 a terrible fire destroyed all the works at the Encino mine, burying numerous victims. This unfortunate accident coincided with the decadence of the district, so noticeable during the XVIIIth century, which was caused by the impossibility of draining the mines to any great depth.

To control at that time this element, which has always been the cause of serious trouble, they had to increase the means of pumping, and to employ animal power, a fact which was always a barrier to exploitation.

In spite of these obstacles, some of the mines resumed their work at a shallow depth and on a small scale, and continued it until the beginning of the war of independence, when all work was completely paralyzed—the greater part of these mines having been owned by the Spaniards. In 1812 the insurgents pillaged the Royal Safes and stole the records from the files. This paralysis lasted until 1824, when the third Count of Regla and a celebrated English miner, who had organized a company in London, continued the work, not, however, without serious difficulties and accidents, and heavy expenditures. Machinery for draining the mines (the transportation of which at that time was very difficult); the purchase of mines in bad condition; and the construction of expensive buildings, were among the items of outlay. Rich ores were the only available ones; the salaries of the technical clerks were high; the dead-work was large; and the administration was complicated. The result of these causes was the ruin of the company, which was dissolved in London in 1848 with a deficit of $5,000,000 and a total loss of more than $11,000,000.

In a short time a new company was formed, and resumed work on certain mines, among which was the "Rosario" (still worked). On the continuation of the famous vein Xacal, at the conjunction of the two branches, this company immediately discovered abundant and rich ores. In the San Nicolas shaft on the same vein and in the region of the *bonanza*, they installed in 1853 a balancing pump which permitted the work to reach a depth of 200 meters, continuing along the *bonanza*. Immediately afterwards work on the Xacal mine was continued,

giving excellent results in 1863. After this time, the number of producing mines on different veins augmented progressively; and in 1895 this district became one of the most important in the New World for its enormous production.

About 1879 the Santa Gertrudis *bonanza* was discovered, producing unusual excitement in mining circles in that locality and a rapid increase of population, which was accentuated by work on a new *bonanza* at San Rafael mine, actively pushed since 1883. These mines yielded in less than 25 years about two million tons of ore.

The exploitation of these immense *bonanzas* resulted in the completion of the Hidalgo railway, which gave Pachuca direct communication with the capital of the Republic. A little later, two new lines were opened to the public, a branch of the Vera Cruz railway and also the Mexican Central, assuring direct communication with the Gulf of Mexico and the United States. The flourishing condition of Pachuca was abruptly interrupted at the close of 1895 by a disastrous inundation in the cañons of the Vizcaina vein, which soon invaded the works of the other mines. The fatal results of this unfortunate circumstance have exercised a powerful influence on the mining affairs of the district; and since that date the decadence of Pachuca has been manifested by the diminution of the Government income and taxes, dullness in commercial affairs and decreased activity in the mills.

The principal mining companies at present established in Pachuca are the Real del Monte and Pachuca Mining Company (the largest one on account of the number of mines which it has in operation and its important management), the Santa Gertrudis, Maravillas and San Rafael Mining Companies.

Pachuca occupies the first place in the mining districts of Mexico on account of its variety and amount of machinery, number of draining-plants, different milling-plants, and its electric power recently inaugurated. It is also remarkable for its numerous shafts, extensions and methods of working. Its drifts, excavations and cuts represent not less than 300 kilometers in length. According to a rough calculation recently made, Pachuca has produced since its first discovery more than 3,500,000 kilos of silver.

III. Topography.

The Pachuca range of mountains, on the slopes of which lies the city of that name, forms the northeastern boundary of the Valley of Mexico, and is considered as a branch of the eastern chain of the Sierra Madre. The crest of the mountains extends approximately NW.–SE. The attention of the traveler has always been attracted, not only by the extraordinary abundance and richness of the mineral veins (of which Pachuca district contains only the smaller part), but also by the beautiful variety of the mountains, either covered with exuberant alpine vegetation or naked, with gigantic and fantastic cliffs, intersected by deep cañons and lovely valleys of delicious climate and even temperature, where small towns have been built. The Pachuca range, whose beauty can be admired from any of its peaks, is one of the most attractive parts of the Central Table-land.

From the abrupt peaks of the Organos de Actopam, which are seen in the distance from the railroad, on the northwest, to the slopes and prolongations of the Navajas mountains on the southeast, the principal range is 40 kilometers long; and at both extremes it joins with other important orographic elements.

On the crest of the range rise peaks and plateaus to a considerable height above sea-level; for example, San Cristóbal mountain 2880, Las Ventanas del Chico 3086, Cerro del Zumate 3057 and Las Navajas 3212 meters. For their remarkable beauty we may mention the magnificent forests which surround the Chico mining district (two hours and a half from Pachuca), from which rises a succession of steep rocks, called, with good reason, "The Nuns;" La Sabanilla, a small plateau surrounded by rocks and situated at the top of the range; the rocks near Real del Monte, and the splendid table-lands of Las Navajas, commanding the beautiful panorama of the valley of Tulancingo below and the grand cañon of Metztitlán.

IV. Geology.

In Mexican territory there are numerous mineral regions which resemble those of Pachuca, not only in the age and character, but also in the condition and origin of the rocks which are cut by veins. With few exceptions, therefore, the

description of one gives an idea of others. All of the Pachuca range is formed of volcanic Tertiary rocks which can be classified into three well-defined types as andesites, rhyolites and basalts. The andesites offer a great variety of colors and appearances due to small variations of structure and composition and to different degrees of alteration. The normal type of this class is green and highly porphyritic, by reason of large crystals of feldspar and pyroxene contained in a microlitic magma with amorphous matter, which latter may diminish in amount so as to permit the rock to be considered as holocrystalline. The phenocrysts are generally labradorite, often transformed into argillaceous or clayey products, or into sericite, with some calcite, chlorite and epidote, which is almost always observed in the interior of the crystals. The pyroxene is also changed with more frequency into chlorite, viridite and epidote, and sometimes into calcite. The magma contains microlites of oligoclase with grains of oxide of iron and sometimes augite microlites. The quartz appears in these rocks either from a primary element in the shape of corroded crystals, or as the result of a secondary impregnation of silica, taking place during the filling of the fissure, by mineral deposition or during the decomposition of the rocks. Other andesites of dark gray or green color, divided into thin slabs running parallel with the veins, contain large quantities of grains of iron in the magma, and more augite microlites and less silica than those mentioned above.

The green andesites present a uniform appearance at all depths with the same kind of alteration, showing that the causes which have produced modifications have produced everywhere more or less, with the same intensity, truly metasomatic changes occasioned during the formation of the veins and circulation of hot waters, resulting in chemical reaction. The dynamic forces of certain tectonic movements do not fail to show their influence. The superficial alteration caused by atmospheric agencies upon these rocks is also very important and is characterized by an advanced oxidation of the magma; the separation of lime of the feldspars, deposited later in the shape of small veins; and, in a word, by the disintegration of the rocks, whose color changes from green to violet, gray and red.

The rhyolites cover the andesites in many parts of the dis-

trict and are spread out in large flows and, in some places, in dikes. They are seen in Cerezo near Pachuca, in Actopan, and around Real del Monte and Las Navajas mountains. Some of them are highly spherulitic; others are full of phenocrysts, with a tendency towards the felsonevadites; and finally others are lithoidal. Obsidian, pitchstone and tufa are equally abundant, and are always associated with the rhyolites.

The basaltic rocks are the last volcanic eruptions of the Pachuca range. They are found on the slopes of the mountains, having run down a short distance, and have the appearance of very fluid lava. A cap of free olivine basalt (*labradorite*) serves as a crown to the top of the San Cristóbal mountain in front of the city of Pachuca. It was in this rock that tridymite was first discovered by G. vom Rath.

The manner of eruption of the different kinds of rocks is worthy of special interest. It appears that the eruption of the andesites took place through large fissures, opened successively, which permitted not only the lava to flow out freely, but also spread out the cineritic products, such as tufa and breccia, which are principally found on the crest of the range, remaining there in spite of the active subsequent erosion.

The last eruptions of andesite brought out a large quantity of silica, sufficient to transform them into dacite, thus showing the proximity of the siliceous rocks or rhyolites. The latter must have broken the andesite crust, and formed during the eruption a wide streak of breccia, as they are seen at present on the crest of the range for a distance of about 12 kilometers. While these fissures were open to let the rhyolites pass out, some other openings parallel and adjacent to these were produced; and it is through them that the phenomena inseparable from these eruptions took place, such as fumaroles, and the circulation of streams of siliceous hot water, bringing from the depths the sulphides, chlorides and other metallic salts that were deposited as incrustations on the walls of the openings.

After a long period of rest that followed these phenomena, lines of less resistance permitted the passing out of the basic lavas, forming at the same time some openings and breaking or distorting the mineral deposits.

We have assumed as a general fact that the andesites of the Pachuca range appeared in the Miocene age, and the eruptions

were the result of the forces that produced the folding of large Cretaceous deposits found in the immediate neighborhood of this range, like that of Zoquital range, the mountains near Actopan, in Ixmiquilpan, etc., where the contacts are seen. The foothills of the mountains in front of the Valley of Mexico are covered by a series of deposits belonging to the Pliocene and post-Pliocene lacustral formation which constitutes the bottom of this vast basin.

V. Vein-Phenomena.

One system only of fissures or openings running more or less east and west comprises the principal veins of the Pachuca district. From the main parallel veins branch out other secondary and less important ones at angles of about 30°. This region is not less uniform from a geological standpoint than with reference to the mineral deposits, which present the same character and structure in all parts. The argentiferous lodes of Hungary and some of the United States, with which those of Pachuca have been sometimes compared, are more complex in their nature and conditions.

In these veins or lodes the quartz forms the principal part of the mass. We can classify them as properly fissure-veins with quartz matrix.

This system of openings or fissures may easily be divided, according to their situation and importance, into four groups, closely joined; but each characterized by a main opening, to which some other smaller ones are attached with a little different direction, as before stated. These groups we call la Vizcaina, el Cristo, San Juan Analco and Santa Gertrudis.

A fifth group may be added, having as principal lode the Polo Norte, situated at the extreme north of the district, near the top of the mountains.

The principal veins of Pachuca are more remarkable for their constancy and extension than for their thickness, which very seldom exceeds 7 meters. The Vizcaina has a length of 16 kilometers from the Barranca de los Leones on the east to the limit of the district of Real del Monte, traversing diagonally the Pachuca range. The San Cristóbal vein can be seen for a distance of 4 kilometers on the surface, and probably extends out under the basaltic rocks of San Cristóbal mountain. It is supposed that the Analco lode follows a line 6 kilometers

long, and continues through the valley of San Bartolo under the volcanic tufa which covers it.

Upon looking at the mining camp of Pachuca, the first thing which attracts one's attention is the alteration of the rocks, generally more advanced near the croppings of the veins.

The fragmentary state of the rocks near the veins, caused by the forces developed during the opening of fissures, accelerates the atmospheric changes; and these rocks have also been modified by the filling-agencies, which impregnated them with an excess of silica. The aqueous and hydrosulphuric vapors passing around through small openings have produced the kaolinization of the rocks; and, finally, the easily oxidizable ores of the veins have also contributed to the alteration.

The croppings of the veins on the surface, generally called by the Mexican miners *crestones*, exceed in height by several decimeters the general surface of the land, especially where the compact quartz prevails, whose white color contrasts with the yellowish gray tone of the land.

The Corteza vein furnishes us with a good example of such projecting outcrop, which, at a certain distance from the streets of Pachuca, may be seen running from the base to the top of Santa Apolonia mountain.

Some outcrops are composed of alternating streaks of pure quartz and highly silicified rock, of which it is difficult for this reason to discern the primitive structure. Undoubtedly it is the same andesitic rock as that of the walls, and was retained in the interior of the veins during the deposition and surcharged with silica by the hydrothermal action which gives them the appearance of rhyolites, as in the veins of Schemnitz.

In the places where the surface is slightly inclined, as at the base of the mountains and on the small plateaus near the peaks, the croppings are covered by *detritus* or by vegetable earth, and there are no signs by which to trace the vein other than a yellowish stain of the earth, or quartz pebbles which have been the result of disintegration of the vein-material.

The Vizcaina lode, one of the most important, rarely has quartz in its surface-zone, and then only in the form of thin veins. Clay is the principal substance with a small amount of calcite. At times the structure is that of a breccia, indicating

a recent filling of the superficial fracture, formerly a cavity. The discovery of this great lode in Pachuca took place accidentally. No one would have thought of finding underneath this mass of *detritus* and clay the enormous treasure enclosed within its depths.

It is well known in Pachuca that the veins not well defined and not containing abundant quartz on the surface are rich only at depth. This is the case in the Vizcaina and Santa Gertrudis veins, whose *bonanzas* have been found at 100 or 150 meters below the surface.

The quartz croppings almost always carry pyrites, alternating with oxides of manganese and other minerals, always argentiferous, with a very appreciable amount of gold. These veins, thus mineralized at the top, have shown great *bonanzas* from the surface down, and were those which naturally attracted the attention of the prospector from the first days of the Conquest of Mexico, as is shown by the large open workings in the veins of the Cristo, Rejona, Analco, etc., from which the first bonanzas of Pachuca were extracted.

Among the accidents of the veins near the surface the branching-off may be observed at once. One vein is divided into three or more diverging branches, which reunite again farther on, being divided by siliceous rocks which the miners call *caballos* (horses). Amongst the cases which have been described, we may cite here the Rosario Viejo; the Maravillas and Valenciana, which branch off in the shape of an arch; but principally the Analco vein near the Rosario tunnel. In these ramifications one of the branches preserves the general direction of the vein, while the other curves out, forming a circular arch of great radius.

In the Pachuca veins it is to be noted at once that the nature of the ores presents in the vertical sense two zones: the upper composed of oxides (red ores), and the lower of sulphides (black ores). The first zone contains, as principal minerals, outside of iron always abundantly auriferous, oxides of manganese (*quemazones*), chlorides and bromides of silver. The lower zone contains the sulphides of different metals, lead, silver, etc. As will be understood, it generally occurs that at different points in this region the lower limit of the upper zone corresponds to the hydrostatic drainage-level of the country.

The valuable minerals in the upper zone have been principally chlorides and bromides of silver. It is therefore easy to understand the secret of the facility with which the ores are treated by the amalgamation or "patio" process and the consequent active exploitation of the superficial *bonanzas*. In our day, exploitation is confined exclusively to the lower depths of the veins, in the *negros* zone, the only one with regard to the composition and nature of which we now have reliable and complete data, and hence the one to be here described.

We have already said that the veins are in part composed of a compact breccia in the upper and even in the deep regions, on account of actions subsequent to the filling of the fissures—a fact of great influence upon the distribution of the richness and the relative hardness of different parts, which has not escaped the skillful eye of our miners.

The quartz in the veins has a greasy luster and milky color. In the streaks of the side-walls it is sometimes bluish, like chalcedony, or greenish. Many veins carry amethystine quartz either covering geodes or in streaks of crystals radially grouped, which alternate with streaks of white quartz.

Calcite is only found in small quantities as matrix in the Pachuca veins, and is not a constant mineral. It appears in crystals upon the quartz geodes or in small veins filling narrow openings, and, finally, in the last layers of concretions.

Of the sulphides it appears that minerals such as pyrite, galena and argentite, were in the majority of cases deposited at the same time as the quartz, with which they are so perfectly blended that separation is impracticable. It also occurs that the quartz has been deposited alone, the barren quartz alternating with streaks of rich quartz. When closely mixed with sulphide it gives a gray tone or is distinctly white, with fine black spots; and when in payable amounts is called by the miners *azogues*.

Concretionary streaks alternating with barren quartz and *azogues* and parallel and symmetrical to the side-walls may be seen very readily in the old workings in the San Pedro, Cristo and other mines. On the Vizcaina vein, in the Santa Ana mine, the black sulphides fill irregular cracks, which cross the quartz, indicating that the sulphides were the last to be deposited. Fragments of rock displaced from the walls and floating

in the vein are found at all known depths, without any regularity whatever in their distribution, and of all dimensions. The more or less angular character of these fragments demonstrates that they have not traveled any great distance. The concretion of the quartz and of the sulphides, immediately surrounding each fragment, shows the same regularity through the entire thickness of the vein.

Manganese is so abundant in the veins that at times it constitutes the greater part of the matrix. As already observed, it is found at the surface as earthy or compact oxides mixed with the quartz, or isolated in streaks. Towards the bottom, the oxide decreases little by little, being replaced by rhodonite, a silicate of varied structure from compact to fibrous, and shaded red, rose or white.

The ore extracted from the famous Rosario *bonanza* was characterized by the abundance of silicate and oxides of manganese, associated with argentiferous sulphides. Other compounds of manganese are found at times in small quantities, among which are xonaltite, bustamite and rhodochrosite.

From the manner in which the manganese presents itself in the veins it is supposed that it must have appeared after the first deposition of quartz, as it is seldom found near the walls, while in the middle of the veins it is very much mixed with the argentiferous ores which it has served as a vehicle.

When manganese does not otherwise exist in the veins, the lower parts contain it in small quantities between the latest layers of the concretions lining the cavities in the quartz.

In the Santa Gertrudis vein of the Barron mine, barytite has occasionally been found in beautiful crystals at 150 meters depth.

Gradually, as one descends in the veins, the oxide of iron diminishes little by little, and finally consists of simply two narrow streaks adhering to the walls. At the same time the oxides of manganese give place to the silicates from which the oxides of the surface were formed by the dissolving action of the carbonated surface-waters. The oxides of iron and of manganese are always in similar proportions.

Pyrite is very frequent in the mineralized parts of the veins, and also abundant in the rocks in the immediate vicinity of the veins, where it sometimes occurs in granular mass and

sometimes in fine crystals and isolated grains. The existence of pyrite in the rocks near the veins has more than once served as a guide to indicate the proximity of the deposits sought for by extensive explorations.

But pyrite occurring in grains and complete crystals in the country-rock of the walls does not contain even traces of precious metals; while, on the contrary, the solid granular pyrite of the veins always contains them mechanically interspersed. In the barren parts of the veins, an increase in the amount of the pyrite demonstrates the proximity of richer ore. The rich pyrite and the sterile pyrite must have different origins.

The pyrite of the altered rocks in fine crystals is the product of a regeneration. The sulphate of iron which results from the decomposition of the pyrite in the interior may be, under special conditions, in the presence of the organic matter near the surface, again reduced to pyrite.

The granular pyrite of the veins, on the other hand, is always accompanied by other sulphide ores as fine-grained. Galena, argentite and chalcopyrite form the principal ores of these veins; stephanite and polybasite are sometimes found; zincblende seldom exists in the regions so far exploited, and it would appear that its presence indicates impoverishment.

At a depth of 350 meters in the San Rafael and Zotol mines there have been found ores with a little blende and threads of native copper, accompanied by argentiferous base minerals; on the contrary, in the old workings of the San Pedro mine, the blende found was almost entirely free from precious metals.

Native silver is found at all depths; ruby-silver has never been found in the Pachuca veins. This distinguishes the district from other mining regions of the central plateau with which it has been compared, and which are similar even from a geological point of view.

The principal problem of a group of important veins is the distribution of values horizontally, as well as on the dip.

Unfortunately, the data on this point which we have succeeded in obtaining relative to Pachuca are incomplete, because information is lacking concerning the very extensive plans of the old workings, and also on account of the relative neglect

of this subject on the part of the engineers in charge of more recent maps of the mines. Observation and study of the cavities from which there have been extracted great *bonanzas* cannot now be easily made, because they are destroyed or abandoned; neither can it be done in newer workings, which have been filled and fortified to serve as passage-ways to new exploitations. However, a superficial inspection of the horizontal projection of the map of the subterranean works at Pachuca immediately shows that the *bonanza* parts of the veins group themselves in a zone oriented from northeast to southwest, nearly normal to the parallel system of veins, and that these *bonanzas* are distributed in an alternate manner; that is, that the *bonanza* of one vein places itself in front of the sterile portion of the neighboring vein, and so on. By study of the vertical projection, it will be seen that the *bonanzas* group themselves into two distinct zones, namely, the upper zone above the mouth of the shaft of San Juan, and the lower zone, extending to the present works. Some veins (Cristo) have had *bonanzas* in the upper parts only, others (Vizcaina, Santa Gertrudis) in the lower zone only, while the Analco and Corteza veins have had *bonanzas* in both zones.

The contour of a *bonanza* is generally irregular, although it may have a frequent tendency to an elliptic form. Very seldom have they circular or elliptic outlines, and it would never be advisable to designate them as columns or chimneys, as they have at times been called. If we compare the number of *bonanzas* of the upper zone with those of the lower, we find that the former are more numerous. This is contrary to what has been supposed hitherto to be the case in Pachuca, where everyone has believed that in reality the *bonanza* region of Pachuca was to be found at a depth of 100 to 150 meters.

In dimensions, the *bonanzas* vary considerably, Some are of colossal proportions; one of the largest being the San Rafael, which was found at more than 100 meters depth and is elliptic in form, the greatest axis being more than 1000 meters and the smaller 400 meters, with an average thickness of 2½ meters. This *bonanza* has produced nearly $14,000,000 during a period of ten years.

The great *bonanza* of Rosario produced, from 1853 to 1883 (30 years), $28,000,000. From the Encino mine $6,000,000

was produced during the eighteenth century, and above the depth of 200 meters. Unfortunately we cannot furnish any data as to the enormous product of the Santa Gertrudis *bonanza*, which has been, perhaps, greater than that of San Rafael.

The miners employ, to designate the rich parts of the lodes, terms which in themselves give an idea of relative magnitude. The small *bonanzas* of more or less regular form are called *clavos*, "nails." When several are found close to each other they are called *bolsas*, "pockets." The small, rich, isolated parts distributed at hazard in the veins are called *ojos*, "eyes," and the mineralized points *moscas*, "flies." It will be understood that these terms do not have an absolutely precise meaning.

In Pachuca, the impoverishment of the veins at great depth is admitted to be a fact. At the bottom of some of them it has been seen that those composed of sterile galena and blende, although of good appearance, are too poor to pay working-expenses. We believe that by carrying these investigations to a greater depth, there might be found, and uncovered, new *bonanzas*, after removing an intervening portion more or less impoverished. This belief is based upon certain actual developments. For example, in the San Rafael and Maravillas mines, beyond an impoverished portion, there has immediately appeared native copper with polybasic mineral, blende, and notably rich ores (naturally rebellious), showing what would be the mineral composition of the ores of the third zone. This, at no distant date, must be uncovered, thus giving life again to the mineral production of the district, which at the present time suffers in consequence of the crisis caused by an inundation which it has not yet been able to overcome.

Before concluding, let us state that mechanical actions and movements in the veins have produced changes in the nature of the minerals of which they are composed, and phenomena of mechanical transportation have caused accidental richness in the veins, frequently accompanied by products of trituration, called in the district *lamas*, which are at times extraordinarily rich; and, finally, that the parts of the veins originally rich correspond to the more cracked and distorted places, where the fissures were larger, where the veins are less in-

clined, and where they change direction, or where the branches separate. All these elements seem to have shared in determining the location or accentuating the importance of *bonanzas*.

Statistics of the Mining and Metallurgical Industry of the State of Nuevo Leon, Mexico.

(Mexican Meeting, November, 1901.)

[SECRETARY'S NOTE.—The following official tables, prepared by the government of the State of Nuevo Leon, and presented to the Institute at the fifth session of its Mexican meeting, held at Monterrey, November 26, 1901, present in compact form a general summary of the mineral and metallurgical industry of the State for the preceding calendar year, together with a statement of the railway-shipments of ores from January 1 to October 31, 1901, which, in the absence of direct official mining and metallurgical statistics (not yet available for that year), clearly indicates an increased activity and productiveness of these industries. In other words, the mines are reported to have yielded in 1900 a total product of 83,960,169 kilos of ore; whereas, the railway is reported to have carried, in 10 months of 1901, a total of 108,318,647 kilos of ore. At this rate, the railway-shipments for 1901 would amount to nearly 130,000,000 kilos. It is, of course, possible that the railway-statistics include other freight than ores, or that they include duplications, such as would be involved in the record, first of certain ores transported, and afterwards of the "base bullion" produced therefrom. An accurate comparison is therefore impossible; yet, after making all reasonable allowances for such items as have been named, it seems safe to infer that the mining and metallurgical industry of this State accomplished in 1901 a substantial progress.]

TABLE I.—*List and Output of the Mines Operated During* 1900 *in Nuevo Leon.*

Name.	Locality.	Metals.	Ore Mined. Kilogrammes.	Value. Pesos.
La Blanca y Anexas	Agualeguas.	Silver & lead.	194,820	13,662.14
Hidalgo	Aramberri.	Copper.	5,000	250.00
El Rosario	Carmen.	Silver & lead.	400,000	4,000.00
Los San Pedros	Cerralvo.	" "	500,000	5,000.00
Buenos Amigos	"	" "	100,000	10,000.00
El Oso	"	" "	25,000	2,500.00
La Libertad	"	" "	31,092	620.00
San Isidro	"	" "	30,380	2,734.20
Santa Isabel	"	" "	16,600	1,006.67
San Juan y Anexas	Doctor Arroyo.	" "	1,455,104	29,102.08
La Esperanza	Lampazos.	" "	150,000	11,000.00
Sacramento	"	" "	36,000	1,000.00
La Voladora	"	" "	20,000	400.00
La Realidad	"	" "	60,000	1,800.00
Flor de Peña	"	" "	200,000	6,000.00
La Plomosa	"	" "	51,000	1,552.00
El Refugio	"	" "	5,874,692	219,869.59
Zaragoza	Monterrey.	" "	2,144,000	54,300.04
San Martín	"	" "	35,940	1,249.23
San Marcos	"	" "	966,600	8,935.08
San Felipe	"	" "	1,143,270	24,301.85
Ampliación de San Pedro.	"	" "	31,938,337	416,915.33
San Pablo	"	" "	3,576,025	58,688.84
Denver	"	" "	449,728	2,921.03
Miguel Escobedo	"	" "	333,355	8,572.45
Carmen	"	" "	216,650	5,093.06
La Voladora	"	" "	1,840,000	59,000.00
La Unión	Mina.	" "	60,000	1,200.00
Soledad y Anexas	Sabinas Hidalgo.	" "	5,416,539	140,690.00
Santo Domingo	Santa Catarina.	" "	600,000	9,500.00
Buena Vista	" "	" "	2,612,000	20,000.00
Santa Gertrudis	" "	Zinc.	1,403,300	9,000.00
San Marcos	Villaldama.	Lead.	10,000	100.00
Montañas	"	"	1,278,377	25,042.62
Don Gaspar	"	"	5,196,600	67,548.33
Buena Vista	"	"	7,581,290	49,623.47
Morenos	"	"	2,078,640	22,865.04
San Juan	"	"	306,200	4,593.60
Guadalupe	"	"	3,118,407	86,030.60
Bocanegra	"	Iron.	2,001,503	9,039.55
San Francisco	"	Lead.	503,720	5,039.83
	Total		83,960,169	1,400,746.63

TABLE II.—*List and Product of the Metallurgical Works Operated During* 1900 *in Nuevo Leon.*

Name and Locality.	Class, Weight and Value of Product.						
	Gold.		Silver.		Lead.		Total Value. Pesos.
	Kilos.	Pesos.	Kilos.	Pesos.	Kilos.	Pesos.	
Gran Fundición Nacional Mexicana, Monterrey	658.653	444,865.16	238,157.723	9,727,864.24	23,021.154	1,012,930.00	11,185,659.40
Compañía Minera Fundidora y Afinadora "Monterrey," S. A., Monterrey	473.289	319,666.96	140,870.897	5,763,732.75	12,510.054	688,052.48	6,771,452.19
Benavides, Cerralvo	....	....	541.534	18,953.69	541.534	81,230 10	100,183.79
Total	1,131.942	764,532.12	379,570.154	15,510,550.68	36,072.733	1,782,212.58	18,057,295.38

TABLE III.—*Monthly Mineral Shipments over the Mineral Railway from Jan.* 1 *to October* 31, 1901, *Inclusive.*

Months.	Kilogrammes.
January	9,698,756
February	8,996,460
March	12,050,451
April	10,976,740
May	9,960,350
June	10,879,920
July	11,780,520
August	12,484,160
September	10,347,310
October	11,143,980
Total	108,318,647

The Pachuca Stamp-Battery and Its Predecessors.

BY M. P. BOSS, PACHUCA, MEXICO.

(Mexican Meeting, November, 1901.)

OF the two methods of mechanical reduction—that of percussion and that of abrasion—it is not easy to say which was first employed by primeval man. The stone hammer and the flat or hollowed stone used for grinding are found together in the remains of prehistoric periods. But the use of the *maray*, or bucking-stone, developed from the hammer, was probably introduced later than that of crude millstones. Diodorus Siculus, the Roman historian of the first century B. C., mentions such millstones as used in the mines of Egypt to pulverize material which had been previously broken in a mortar.

The invention of the arrastra for fine grinding is declared by some authorities to have been made by Bartolomeo de Medina, at Pachuca, Mexico, about A. D. 1557—which is quite probable. Being the first to amalgamate silver on anything like a business scale, he must have felt the necessity for ore-grinding apparatus of greater capacity than the old primitive millstones; and the arrastra was thus the natural successor of the millstone.

It is very unfortunate that the archives of Pachuca, which has made so much history in ore-treatment, were destroyed in some one of the many insurrections for which, also, the place is renowned.

The first application of the stamp to the crushing of rock is asserted by some writers to have been the invention of a Saxon nobleman named Von Maltitz, about the year 1505. Better authenticated reference, however, is made to one Paul Gronstetter, a native of Schwarz, and called an ingenious worker, who, in the year 1519, established at Joachimsthal a process of wet stamping and sifting. Two years later, a larger plant was established at the same place. It is said that he had previously introduced the same device at Schneeberg. How much of the invention was due to Gronstetter is not certain;

but it certainly seems that he was the first successful operator, and that it rapidly came into extensive use, as a direct result of his operations.

Whether the stamp-mill was then practically as we find it profusely illustrated in the work of George Agricola, some years later, or whether it had been further developed by other hands in the interim, we are not informed. But for more than 300 years the stamp continued to be a square timber (except in a few instances, where square iron was used) with an iron shoe at the lower end. In this form it came to crush the first gold-ore of California.

As soon as stamps began to fall on California gold quartz, brains began to work for their improvement. There was in those days so little system and so much crudeness of construction, as well as secrecy of methods, that the early improvements can be traced with difficulty. Previous to the general adoption of the round revolving stamp, numerous departures had been made from the original imported type. One style came into vogue in the territory around Marysville, Cal. It was square, and had two stems, driven with a taper into the head; and the rectangular tappet was held by cross-keys, one for each stem. The stems were cross-slotted to engage the keys. Some of these stamps weighed as much as 1000 lbs. each. The shoes were held by a square taper shank.

An article of considerable fullness, by C. P. Stanford, in the San Francisco *Mining and Scientific Press* of October 21, 1893, shows conclusively that that gentleman was the inventor of the round stamp; but it was not made to revolve until this feature was suggested by Isaac Fisk, an engineer in his employ.

The U. S. patent granted July 4, 1854, to Joseph L. Laird, for an improvement in ore-stamps, claimed "the arrangement of the lifters by being so placed as to operate on the periphery of the tappet-head for the purpose of giving the stamps a partial rotation without requiring other mechanism in the manner set forth." This inventor very likely found his patent invalid for lack of novelty. At all events, no instance can be found of his claiming royalty for the thousands of stamps which were in use, with this improvement, during the life of the patent.

After the introduction of the round stamp, Mr. Zenos

Wheeler devised a means of holding the tappet by screwing it upon the stem. Later, when having a large stamp-mill built at the Miners' foundry, in San Francisco, he accepted the advice of Mr. H. B. Angel and had it made with a gib and two cross-keys in the tappet. Years later, Mr. Irving M. Scott cast the gib into the tappet, making it shorter and entirely enclosing it at the ends, thereby securing it against maladjustment, as well as simplifying its construction.

In 1857 Mr. Samuel J. Black, complaining of the faultiness of all cams hitherto made, requested Mr. H. J. Booth, of the Marysville foundry, to make a cam that would at all times bear only on a diameter-line of the tappet parallel with the cam-shaft. Mr. Booth got the lines for such a cam by means of a board revolved upon a center corresponding with the cam-shaft center, locating his points with a dummy tappet, working upon a slide. Of course, this gave practically an involute curve. The first double-arm cam, made as they are made to-day, with the hub on one side, to bring the stamp nearer to the shaft, and laid out as an involute, was designed by Mr. Irving M. Scott.

The high-box mortar is thought by some to be due to Mr. Zenos Wheeler; but positive information on this point is unattainable. Nor is it to be ascertained to whom is due the introduction of the long battery-foundation blocks, set on end.

This outlines the evolution of the world-famous California stamp-battery. It has continued, and still continues, to undergo a gradual refinement of detail, and it has become cosmopolitan.

Judged from the standards of the present day of technical schools and highly-developed mechanics, the evolution of the California stamp seems but a trivial and simple matter; but at that time it was an important step up the ladder of progress.

Sixteen years ago the writer became an advocate of concrete foundations and low-set guides for stamps, and, three years later, took the opportunity to apply these principles to the original *Hacienda de San Francisco*, of Pachuca.

This first foundation, however, was not an unqualified success, the concrete having been insufficiently rammed; but it was a guiding star for the erection of the new *Hacienda de San Francisco*, built at Zotol. This mill began crushing ore the 1st

of May, 1894, has been in practically constant operation ever since, and has made a record, in some respects very remarkable. It was built with 20, and in the following year increased to 30 stamps. During these seven years, only four stems, all told, have been broken, and one renewed; and the stems are not seriously worn in the guides. The stamps, when new, weigh 1040 lbs. each, and make 102 drops per minute. Each stamp has therefore dropped about 450,000,000 times, without renewal of stem or guide.

For this result I assign three causes:

1. The long stamp-head and low guide prevent severe wrench to the stem when the stamp strikes hard at one edge of the shoe.

2. The solidity of the concrete foundations keeps the jar and vibration of the iron-work at a minimum.

3. The iron guides give the stem but little play.

At the *Hacienda de San Francisco*, now running, the concrete was laid upon solid bed-rock, and was 9 ft. in depth and 9 ft. in width. It was very thoroughly rammed as laid. On a hard bed-rock there is no necessity for deep concrete, except to secure the required height: in fact, no foundation could be better than a solid, unfailing granite bed-rock, with only a thin sheet of rubber or canvas between it and the mortar. With a mortar having a fairly thick bottom, this would make a perfect anvil for the blows of the stamps.

The top of the stamp-head in the *San Francisco* is only 2 in. below the lower guide when the stamp has new shoe and die, and is raised 6 in. for drop. This, of course, requires that the housing shall be around the stamp-head instead of around the stem—which is easily effected with a long stamp-head.

Guides of iron themselves wear so little, and also wear the stem so much less than wooden guides, that they are beyond comparison better. For example, how thick would a stem be, after running seven years in wooden guides, without repairs or alteration in length? The reason that wooden guides wear the stem so much faster than iron ones is that they accumulate grit, whereas an iron guide becomes smooth and polished.

An Adobe Reverberatory Furnace.

BY JOHN GROSS, SOMBRERETE, ZACATECAS, MEX.

(Mexican Meeting, November, 1901.)

THE building of reverberatory furnaces (*Fortschaufelungsöfen*) where ordinary brick, fire-brick and iron are comparatively cheap, is quite a different matter from the building of such furnaces in isolated camps, where proper material is only to be obtained at high cost and with long delays. Time is always a large factor in metallurgical operations, and the metallurgist may find himself in a position where it becomes necessary to erect apparatus and have it running in less time than it would take to obtain material from outside. It is here that he must make use of makeshifts.

In Mexico, one of the most important of these is the all-useful adobe. Employed from prehistoric times, it still has its sphere of application in a surprisingly large number of instances requiring an article that can be quickly and cheaply produced.

It is quite possible to erect serviceable reverberatory furnaces with no other materials than adobes, stone and wood.

The old Mexican smelting shaft-furnace was an example of what can be done with adobes, and the large number of ruins of this class of furnace scattered through the mining districts of Mexico are silent testimony to the genius of a people who demonstrated their capability of adapting material at hand to their needs.

The present paper will describe briefly the construction of an adobe reverberatory furnace which is giving good results, can be quickly erected at a low cost, and, if properly built and handled, will last a long time.

The material being simply sun-dried, it naturally follows that the construction must be quite heavy. The adobes should be evenly made, with just sufficient straw to hold them together, and not too large in size (9 in. wide, 18 in. long and 4 in. thick

is very convenient). The binding-material should be of the same clay as the adobes.

The drawings explain themselves. Fig. 1 is a ground-plan

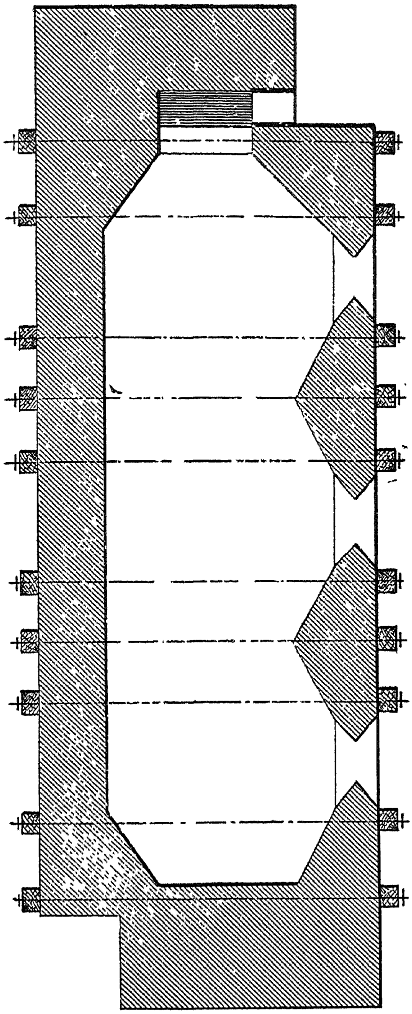


Fig. 1

Adobe Reverberatory, Plan. Scale, ⅛ in. = 1 ft.

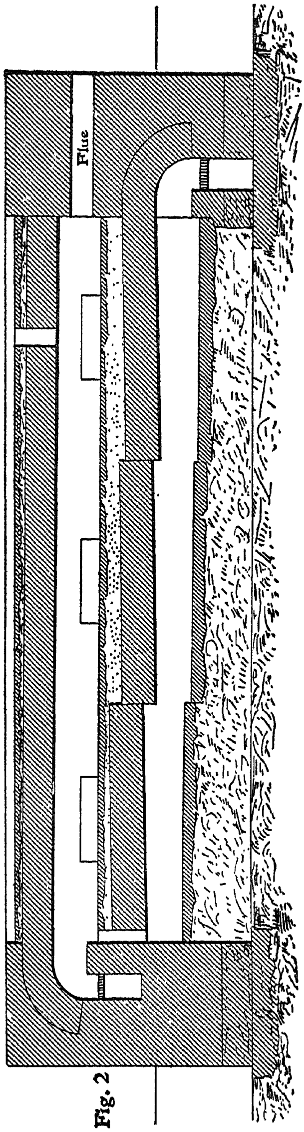


Fig. 2

Longitudinal Section.

through the lower hearths; Fig. 2 a longitudinal section; and Fig. 3 a cross-section.

The furnace is double-decked, with three hearths on each deck and an auxiliary fire-place for the upper deck. It is

designed for wood firing and chloridizing roasting, and is operated entirely by manual labor.

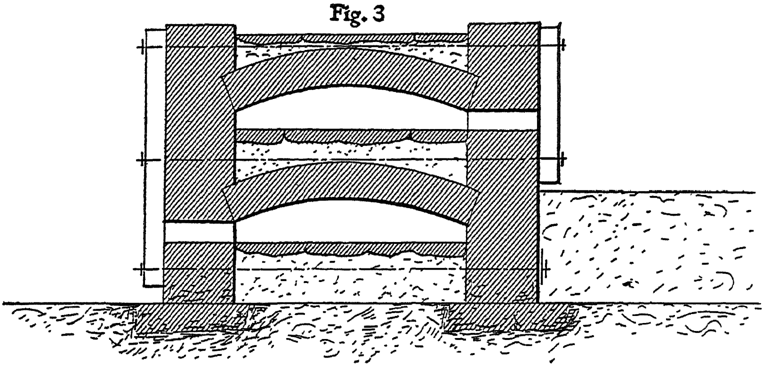
The ore is charged through a hole in the roof, worked in charges of 1200 kilos, and finally drawn through the last rabbling door into wheelbarrows, to go to the cooling-floor.

Naturally, different ores and conditions would suggest other modes of building and manipulation; but the object of this paper is simply to show this particular furnace as it is.

The hearths are 10 by 10 ft. in size, with 3-ft. walls, making the furnace 16 ft. wide and about 41 ft. long. The arch springs 9 in. above the hearth floor, and has a 12 in. rise.

The foundation is of stone, well-built on a solid footing, and carried up to the first set of buck-stay rods. These 1-in. iron

Fig. 3



Adobe Reverberatory Furnace, Cross-Section. Scale, ⅛ in. = 1 ft.

rods are placed in pipes or channels, to prevent their burning out, and to permit them to be easily changed if necessary.

The outside walls of adobe are now built up to the top of the lower skew-back, when the floor of the hearth, which consists of a "fire-stone" set in clay, is put in. Each hearth is stepped a few inches lower than the preceding one.

The center (of dirt) for the arch is now put in, and curved to templates. A 10-ft. span of arch should not have less than 12 in. rise. When the center has been satisfactorily placed the skew-back is cut, and the arch is built of "arch"-adobes, placed upright, and making an 18-in. arch. This arch should be carefully built, using as little mud (made from screened clay) for joints as possible, and hammering adobes in place with a block of wood.

After the arch has been well keyed, the middle buck-stay rods of 1-in. iron are placed in pipes just over it, and the walls are carried up to the top of the skew-back of the upper arch; the upper hearth-floor is put in; the center is placed as before; and the upper arch is built of the same size as the lower one. The upper rods of 1-in. iron, just over the upper arch, need not be put in pipes; however, it is convenient to do so. The top of the furnace is paved with flagstones.

The buck-stays of 10 by 10 in. timbers are now put on; the rods are tightened thoroughly; and the centers are removed by boys, getting into the furnace through the fire-box, after this has been cleaned out.

A light fire is started and kept going one day in the lower fire-box, and then in the auxiliary one; the lower fire being increased. After three days of gradually increased firing, during which time steam and water are likely to appear in a few cracks, and the rods are occasionally tightened, a charge of ore is put on each hearth. The sulphur, soon igniting, will in a day or two, with proper firing, bring the furnace up to a temperature sufficient to begin operations. Some 4 or 5 days more are required, however, before the furnace is properly heated, owing to the enormous body of adobe-work that must be brought up to proper temperature.

The rods must be looked after to see that they are kept tight, or, if they burn out, that they be replaced. The enormous weight of the arches will cause their gradual sinking, if not properly held, but they sink very slowly and give abundant notice.

Views of an Old Smelter in the State of Morelos, Mexico.

BY C. W. PRITCHETT, STEAMBOAT SPRINGS, COLO.

(Mexican Meeting, November, 1901.)

SEVERAL years ago, during a trip from Jojutla to Huauatla, in the state of Morelos, Mexico, I was told by my guide of the ruins of an old smelter near by, and my curiosity was excited to such an extent that I went out of my way several miles to see them. I found them very interesting; and, as I fortunately

had a few plates and a camera with me, I was able to obtain a few views which may be interesting to others, as showing what was being done in the sixteenth century in the way of smelting in Old Mexico. The date on the old church near by is 1540, and it is believed that the smelters were erected about the same time by the Jesuit fathers. The church is still in use, but I was unable to get a view of it, as I had used up all my plates on the smelter.

The smelter is about 10 miles east of the town of Jojutla, on the Ixtoluca river. Fig. 1 shows an old stone bridge over this river, on the road leading to the smelter. The bridge is just wide enough for one animal, and has, at the first pier on the west side of the river, a short turn, which can be discerned in the picture. The plant was an extensive one, even according to the notions of to-day.

In what seems to have been the smelting-department are still standing the stone and mortar housings of three large overshot water-wheels about 15 feet in diameter. Water was brought from the river by a splendidly constructed ditch about 3 miles in length. At the river, portions of an excellent dam are still standing. Arrangements were made for the water to flow in small canals along the tops of the division-walls of the building; and, in many places in the building, a connection was made through the legs of the arches with the upper canals, so that, apparently, by pulling out a wooden stopper, water could be had in various parts of the *hacienda.*

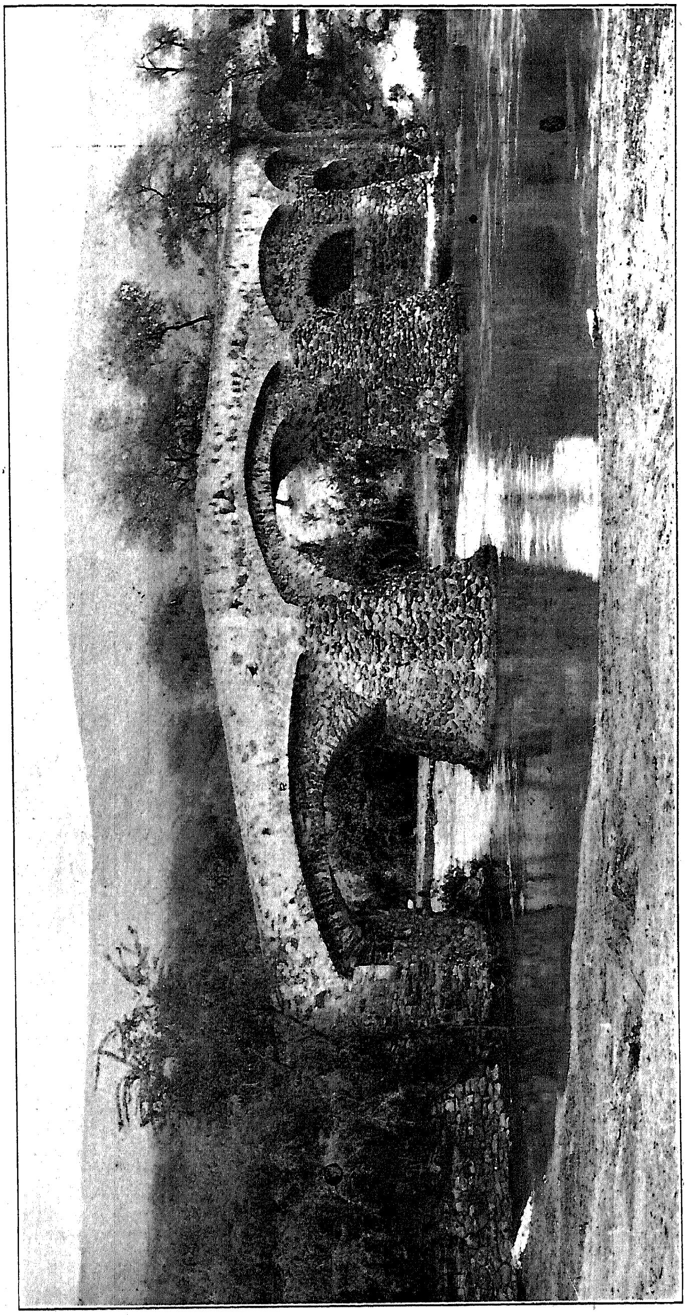
Fig. 2 is a view taken from a stone staircase in the smelting-department which communicated with the upper floor. The view looks toward the entrance, and shows an old sundial on the leg of the third arch in the perspective.

Fig. 3 shows the hood of the smelting-furnace. I was unable to get any views of the furnace under the hood. The notable absence of slag, and the arrangement of water-canals at the base of the furnace, suggest that slag-granulation may have been practiced here.

Fig. 4 shows three reverberatory roasting-furnaces, with separate chimneys, arched backs and sloping hearths. For grate-bars, slabs of igneous rock were used, slanting toward the door. Fig. 5 is a nearer view of one of these furnaces.

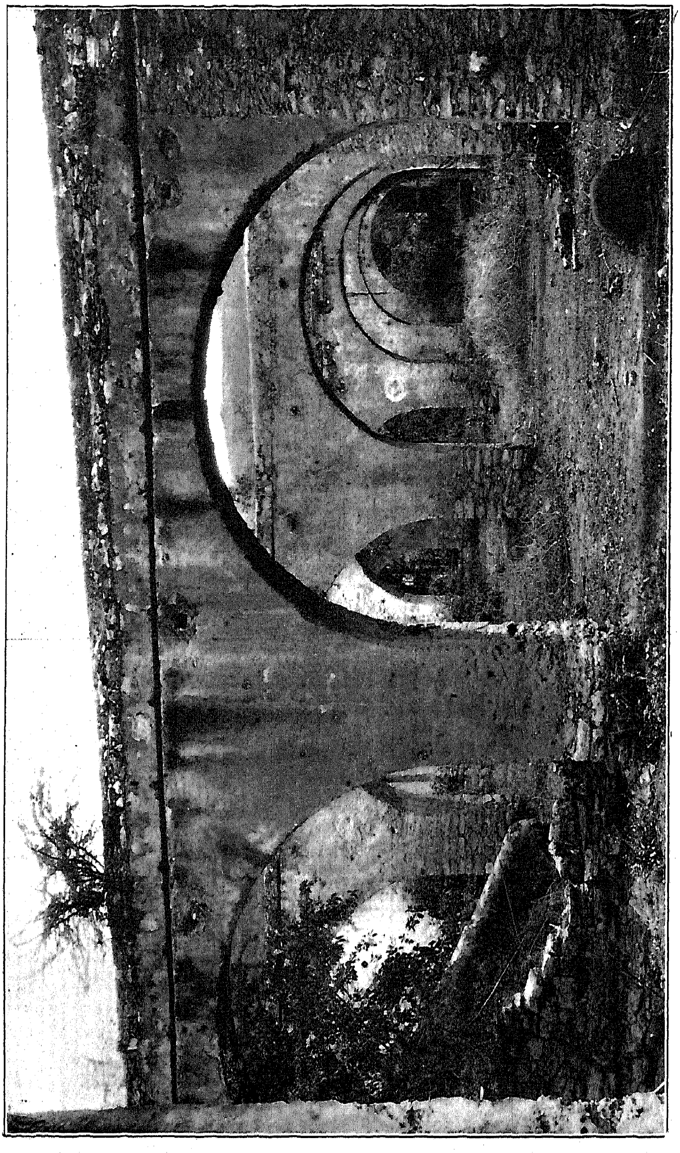
Fig. 6 is a view of what was to me the most interesting

FIG. 1.



Ancient Stone Bridge over the Ixtoluca River, Mexico.

Fig. 2.



Interior View in Smelting-Department.

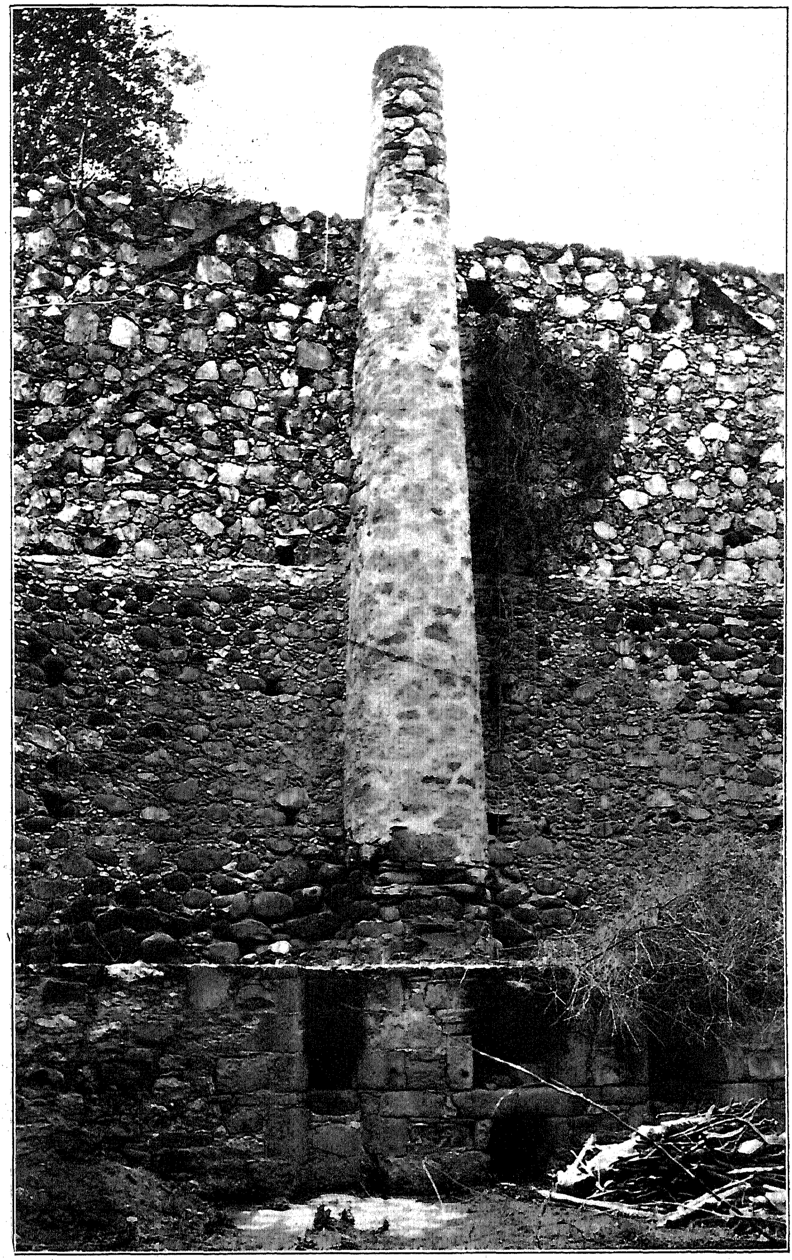
FIG. 3.

Hood of Ancient Smelting Furnace.

FIG. 4.

Three Reverberatory Roasting-Furnaces.

FIG. 5.



Reverberatory Roasting-Furnace. (One of those shown in Fig. 4.)

Fig. 6.

Old Stone Stamp-Mill.

feature of this *hacienda*, a stone stamp-mill, probably the oldest in existence on the continent. It seems that this battery may have consisted originally of four stamps, but that part of it was walled up and only two stamps were used. The mortars were of stone and could be removed when worn out. The stems were evidently of wood, and 4 to 5 in. square, as indicated by the square holes in the arch above each mortar. The stamps were evidently raised by hand and allowed to drop. Back of the mortars is a small room, evidently for ore and the feeder. The roof above is reached by stone steps, and, judging by the worn places around the guide-holes, the men who raised the stamps probably stood up there. In front of the mortars, for a distance of about 30 ft., are still portions of an inclined plane of stone, with riffles cut in it, which was probably used for concentration.

It seems probable that this plant was built to treat the ores from the mining camp of Huauatla, about 20 miles distant.

The Mexican Railroad-System.

BY VICTOR M. BRASCHI AND EZEQUIEL ORDOÑEZ, MEXICO CITY.*

(Mexican Meeting, November, 1901.)

I. Historical Summary.

The railroad history of Mexico began with the first presidential term of General Diaz. Concessions for the building of railroads had been granted in former years; indeed, an exclusive privilege was granted, August 22, 1837, to Francisco de Arrillaga for the construction of a railroad from Mexico to Vera Cruz, with a branch to Puebla, and other concessions were granted from then on at various periods; but the year 1877 was the real beginning of the regular and constant development of the railways of Mexico.

The programme laid out at that time by the new government, and responded to by the nation, was to develop its natural ele-

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* Secretary's Note.—Sections I. and II. of this paper were written by Mr. Braschi; Section III. by Sr. Ordoñez.—R. W. R.

ments of wealth; to repeople the national territory which foreign wars and internal strife had almost depopulated; to cross the land with ample and rapid ways of communication; to open new markets to Mexican products; to increase internal trade; to end at once and forever fiscal penury and its fatal, and until then inevitable, consequences; to re-establish the lost national credit; to diffuse popular instruction; and, finally, to promote in every way public and private prosperity, thus redeeming the nation from the double slavery of ignorance and poverty, and elevating it, through its wealth and power, to the high level that it ought to occupy among civilized nations.

To establish and insure peace, it was necessary to join the integral parts of the country by means of rapid ways of transit, a military strategical necessity, because, in the words of General Diaz, "unstable and changeable governments, incapable of protecting life and property, either end in absorption by a stronger people or use themselves up and disappear, without leaving in history other traces than sometimes those of their heroism, but more often the remembrance of their misery and sufferings."

Moreover, beyond their military significance, such means of rapid and easy internal transportation, permitting freedom of travel, trade and correspondence, would stimulate enterprise, increase production, and promote the growth of both general intelligence and national wealth.

The technical problem of Mexico's rapid and economical means of communication was not difficult. On the map, Mexico has the shape of a leg of mutton, wide at the north; its coast-lines joining in curves to form to the south the isthmus of Tehuantepec; without navigable rivers, except in the narrow and uncultivated mountainous and tropical regions of the south; and with two formidable systems of mountains parallel to the coasts, forming in the center of the country the great table-land of Mexico, inhabited by about half the total population. This table-land has the same general shape as the country, namely, an oblique triangle, with its base upon the northern frontier of the Rio Grande and its apex about in the valley of the City of Mexico. South of this valley the two coast-systems of mountains mix and join, so that the rest of the country down to the isthmus of Tehuantepec is mountainous, with the ex-

ception, of course, of the flat coast-fringes. The central table-land is not absolutely level, but slopes northward to the Rio Grande, and is crossed by numerous separate systems of mountains and hills, independent of the two coast-ranges.

The population of Mexico is distributed roughly as follows:

	Per cent.
Central States,	47
Pacific Coast States,	33
Gulf of Mexico States,	12
Northern Frontier,	8
Total,	100

In 1877 the central table-land, containing about half the population, and which is the true and typical Mexico, was thus separated from the coast by two systems of mountain-ranges, and its own principal subdivisions were separated by long distances, occupied by large, uncultivated, and almost desert territories. The north, with its long, thinly-settled frontier, and only 8 per cent. of the total population, was indeed a free and wide field for insurrection and smuggling. The Pacific Coast States, with one-third of the population, were entirely separated from the rest of the country by the Sierra Madre mountains. These physical barriers, of course, still remain; but statesmanship and enterprise have so far overcome them that they are no longer absolute barriers. It is as if they had been half-obliterated.

Mexico, therefore, was then a nation composed of almost independent provinces or petty States, united only by a common language, origin and history, and by memories of a common resistance to two foreign aggressions, notwithstanding which, they tore each other up in internal fratricidal wars. These States, separated by difficult mountains and extensive deserts, had accentuated their natural isolation by raising against each other artificial walls in the shape of interior custom-houses; and their highways were infested by bandits, encouraged by the long intervals between cities, and by repeated revolutionary disorders. When the modern history of Mexico began in 1877, the country was anxious and ready for a change.

The topographical and geographical distribution of the population being such as we have seen, and no navigable rivers ex-

isting in the populated portion of the country, the engineering scheme for rapid ways of transit proposed, of course, a net of railroads. This was composed, broadly speaking, of the following systems:

1. Lines which, starting from various points on the northern frontier upon the Rio Grande, should cross the great central table-land, converging to the capital, the apex of the triangle of the table-land. These lines would join the capital to the central and northern States, and, crossing vast uncultivated territories, would connect with the railroad-systems of the United States.

2. Lines which, starting from the Gulf of Mexico, should climb the east or Gulf range of mountains, to join the central table-land with the Gulf.

3. Lines which, starting from the City of Mexico and its neighborhood, should invade the mountainous regions of the South and South Pacific.

4. Lines which, crossing the Sierra Madre from any possible point on the West, should join the Pacific Coast with the center and the Gulf.

5. Subsidiary lines and branches.

In general, these theoretical railway-schemes had, of course, been understood in early days; and, as already stated, a concession had been granted in 1837 for a railroad from Vera Cruz to Mexico,—the line which had always been considered indispensable, since Vera Cruz had always been the chief port of the Republic; but nothing of practical import was done until 1877, when the Government wisely began the granting of pecuniary assistance to railroad-building as a regular official policy.

When the new government of General Diaz took hold of affairs, the only completed through line was the Mexican railway, 423.75 kilom. long, from Vera Cruz to Mexico. Besides this, there were the branch to Puebla; the line from the Port of Progreso to Mérida, the capital of Yucatán; the short line from Vera Cruz to the Port of Alvarado; and a few kilometers of the Mexican National, just starting to Toluca; making a total length in 1877 (including the lines of the Federal District) of 672.371 kilom., or 417.5 miles. Ten years afterwards the length of railways was 6,608.809 kilom., or 4106 miles.

In 1897 the length was 11,772.642 kilom., or 7311 miles, and in September, 1901, the total was already 15,454 kilom., or 9600 miles.

The amount of subsidies granted up to December 31, 1899, was:

In cash,	$30,145,517 00
In certificates,	28,909,314 53
In bonds,	42,601,546 62
Total,	$101,656,378 15

II. Present Conditions.

Grouped under the five systems above sketched out, the various present lines and branches appear as follows:

1. *From the Rio Grande to the City of Mexico.*

	Miles.
(1.)—Mexican Central: Ciudad Juárez to Mexico City, 1970.44 kilom.,	1225
(2.)—Mexican National: Laredo to Mexico City, 1350.44 kilom.,	841
(3.)—Mexican International: Ciudad Porfirio Díaz to Torreón, 616.55 kilom.,	383

2. *From the Gulf of Mexico to the Table-Land.*

(1.)—Mexican Railway: Vera Cruz to Mexico City, 423.75 kilom.,	263
(2.)—Interoceanic Railway: Vera Cruz to Mexico City, 646.602 kilom.,	340
(3.)—Monterrey and Mexican Gulf: Tampico to Treviño, 624.64 kilom.,	387
(4.)—Mexican Central: Tampico to Aguascalientes (Chicalote), 663.5 kilom.,	412
(5.)—The Hidalgo and North Eastern Railroad belongs also in this system. It starts at Mexico City and goes to Pachuca, branching off at Tepa for Tulancingo, and will eventually reach the Gulf of Mexico at the Port of Tuxpan. Its ramifications, making a unique system, owned and handled entirely by Mexicans, amount in length to 212 kilom.,	132

3. *From the City of Mexico and Neighborhood to the South and South Pacific.*

	Miles.
(1.)—Matamoros Branch of the Interoceanic: Puebla to Tlancualpican, 124 kilom.,	77
(2.)—Morelos Branch of the Interoceanic: Mexico to Ixtla, 216 kilom.,	134
(3.)—Mexico, Cuernavaca and Pacific: Mexico to Rio Balsas, 292 kilom.,	181
(4.)—Mexican Southern: Puebla to Oaxaca, 367 kilom.,	227

4. *Across the Sierra Madre to the Pacific Coast.*

	Miles.
(1.)—Sonora Railroad: Nogales to Guaymas, 426 kilom., .	265
(2.)—Rio Grande, Sierra Madre and Pacific: Ciudad Juárez to Terrazas, 250 kilom., ...	156
(3.)—Parral Branch of the Mexican Central: Jiménez to Stallforth, 134 kilom., ...	84
(4.)—Chihuahua al Pacifico: Chihuahua to Miñaca, 200 kilom., ...	124
(5.)—The Torreón to Durango line of the International: 253 kilom., ...	157
(6.)—The Manzanillo Branch of the Mexican Central, now under construction from Guadalajara, has built 192 kilom., ...	119
(7.)—Occidental Railroad: Altata to Culiacán, 61 kilom., .	38

5. It is unnecessary to mention the various lines and branches that belong in this subsidiary, purely local system, of which the Mexican Northern, between Escalón and Sierra Mojada, may be taken as a type. The branches of the Central throughout the State of Jalisco, and the National's branch to Morelia and Uruapam, in Michoacán, are also of great local importance.

6. A sixth system might be said to consist of the Tehuantepec railroad, owned by the government, between Coatzacoalcos on the Gulf and Salina Cruz on the Pacific, 309 kilom., or 192 miles long—a road that will play an important part in Asiatic trade as soon as these two ports, now in course of improvement, are ready for trans-continental business. This road will be joined shortly to Vera Cruz by the Vera Cruz and Pacific Railroad, which, starting at Córdoba, on the Mexican Railway, will connect with Santa Lucrecia, on the Tehuantepec. About 200 kilom. (125 m.) of this new road are now built.

III. A Railroad Journey.

Under this head it is proposed to give an account of what can be observed by a traveler following the lines of the Mexican railways.* For the sake of clearness and completeness, some features of the topography, etc., already mentioned, are re-stated.

The Isthmian region begins in the Mexican territory, situated south of the United States, between the two oceans. It extends

* This sketch includes, but is not wholly confined to, the route of the special excursion trains which brought the Institute party to Mexico.

to the south by a series of narrow isthmuses, forming Central America, which was probably formerly joined to the Antilles, and constituted, as has been noted by several observers, a region similar to the Mediterranean zone between Europe and Africa.

The general shape of Mexico is that of a strip of land gradually narrowing towards the south, and widening again to the southeast. It branches off towards the Isthmus of Tehuantepec in a very irregular strip of land, which constitutes Central America, and in another, which extends towards the Antilles, and is called the Peninsula of Yucatán.

The Peninsula of Lower California is a prolongation of the coast-line of the Northwestern States, from which it is actually separated by an arm of the sea called Cortes, whose entrance is formed by San Lucas and Corrientes capes, thus establishing not only a geographical extension, but also a strictly geological dependence.

The most rudimentary idea which could be furnished of the general structure of Mexico would be to compare it with an immense continental plateau supported and bounded by two ranges of mountains parallel and close to the littorals of the Gulf and that of the Pacific Ocean.

Our two large chains of mountains, which are orographic continuations of the Rocky mountains, have a tendency to join in the shape of a V, whose branches are united in the network of mountains of Oaxaca. Naturally, near the vertex of this large V is the highest elevation of the plateau, which gradually declines towards the north.

The two mighty mountain-chains, called by Humboldt the Mexican Andes, and well known as the Sierra Madre Oriental and the Sierra Madre Occidental, are not single ranges. Each is a continued series of groups of ranges, or of isolated mountains, separated by cañons and deep ravines traversed by torrential waters. And they present magnificent forests, where one enjoys all climates giving life to the landscape, or arid slopes, scattered with naked rocks, and containing a network of metalliferous veins, which furnished the traditional romantic wealth of the Toltecs, Mexicans, and other opulent aboriginal races.

The great plateau called *Mesa Central* (1700 meters average height above sea-level and 666,000 sq. kilom. in area) extends from the plains of Texas and New Mexico, in the United States,

to the base of the volcano of Xinantecatl, on the Nevado de Toluca, at the foot of which the central plateau has an altitude of 2600 meters.

Deep, splendid cañons through the two great Cordilleras permit the waters of the interior to reach the wonderfully fertile and beautiful coast.

The traveler across the extensive desert plains of Texas finds no variation in the landscape on reaching the right bank of the Rio Grande. The cultivated prairies surrounding the well-painted frame-houses where the cow-boy, the Anglo-Saxon *ranchero*, dwells, the humble hut, lost in the immensity of the Mexican plains, and the cabin of the Indian or creole laborer, are not sufficient to relieve the lonely monotony.

Small streams cross the Mexican Central railway, which, after running many miles through clouds of dust, finally reaches an oasis.

Chihuahua.—This city, the capital of the State of the same name, is the most important in northwestern Mexico. Its 20,000 inhabitants are divided between manufacturing and industrial pursuits, and its prosperity is largely due to the neighboring mining district of Santa Eulalia, formerly famous, and now inaugurating a new period of prosperous productiveness. The City of Chihuahua has been remarkable since 1718. It is the tomb of many heroes of the Independence.

Going south, the railway skirts the plains of *el Bolson de Mapimí*, bounded at this part by the Conchos river, one of the affluents of the Bravo, which crosses the line above the city of *Santa Rosalía;* three hours afterwards, one reaches the city of *Jiménez*, an ancient military post of the Colonial epoch, and at present the junction of the Parral branch. *Parral* is at present one of the most flourishing mining districts of the Republic.

After passing the station of Escalon, the junction of the line to the Sierra Mojada, a rich mining district discovered some 23 years ago, the railway, before reaching the station of Jimulco, traverses the principal cotton district of Mexico, in the region of the plains fertilized by the waters of old lakes, such as Mayran and Tlahualilo, fed by the Nazas river, which rises in the slope of the Sierra Madre, in the State of Durango, and the Aguanaval river, which empties into the Patos and

Parras lakes. This region has been converted into an important manufacturing and industrial center. Our own generation has seen the rapid growth of business towns like *Ciudad Gómez Palacio* and *Torreón*, the latter of which is now the junction of two railroads, of mighty significance and influence in the economical progress of the country.

Torreón is connected with the City of Durango, from which the road to Mazatlán, on the Pacific Ocean, has been projected and begun. It is also the terminus of the International railroad, the other route which connects on the U. S. border, at the City of Porfirio Díaz, with the Southern Pacific. At Reata, this railway connects with the Gulf railroad, which, touching Monterrey, the capital of the State of Nuevo León, and passing through the cities of Cadereyta, Montemorelos and Victoria, arrives at the port of Tampico.

Following the banks of the Aguanaval river, the road leaves the station of Jimulco to enter anew the desert plains, bounded by a horizon of high mountain-ranges, utterly devoid of vegetation.

Camacho.—To the left of this station the peak of Teira, at the base of which narrow auriferous veins are worked, towers from a large mountain range. Behind this mountain are the Zuloaga, Mazapil, Concepción del Oro and Candelaria ranges, which contain important mineral deposits of ancient and modern exploitation. To the right of the station of *Gutiérrez* are seen the low foot-hills of the Western Sierra Madre, beyond which are the mining district of Nieves and Sombrerete, of old mineral development.

The plain changes gradually into valleys less arid and better irrigated; cultivation begins to appear before reaching the lowlands of *Calera*, which is a continuation of the salt plains and bogs of the village of Cos, and shortly before this the station of Fresnillo is reached, not far from the rich mining district of the same name, discovered in 1554 and worked (especially as to the group of veins of Proaño hill) since the 18th century. This mining district has undergone many changes; several important *bonanzas* were extracted in the first half of the 19th century. The workings having had a great development and impulse, it was decided in 1853 to install there the practical School of Mines for students of the Mining School of Mexico.

A little further beyond the station of *Calera* the road begins to ascend towards the foot-hills of the Zacatecas range, until it reaches a height of 2442 meters above sea-level, the highest on the line from El Paso to the City of Mexico.

Zacatecas.—The route of the railroad over these mountains presents a wonderful and interesting panorama. Following the ins and outs of the mountains, it frequently invades the mining claims, whose corner-stones look like white dots on the barren slopes of the hills; improvements, such as stacks of boilers, hoisting-works, roads and trails, are noticed everywhere in the vicinity of the shaft-openings. Finally, the eye is suddenly met by the confused groups of houses of the city, at the bottom of a depression surrounded by high mountains, the most distinguished of which is La Bufa, a mass of rhyolite which crowns the range as a crest.

The cupolas and towers of the churches, the roof of the market and the high façade of the theater tower up in the midst of the houses, which, with their plain roofs, bear at a distance the aspect of a pile of blocks.

This city was founded in 1585; the rich mining district, one of the greatest developed in Mexico, having been discovered by Juan de Tolosa in 1546. Philip I. granted to the city the privileges which those of Castile used to enjoy.

The mining district is at present in the most deplorable state of decline, as is indicated by the imposing ruins of its mills, many of which are located in the Guadalupe cañon, skirted by the railroad.

Aguascalientes.—The line now descends from the Zacatecas range to enter anew the plateaus where pastures and productive fields abound. Three hours later the traveler begins to distinguish the smoke of the chimneys of the great foundries in the environments of Aguascalientes, capital of the State of the same name, an agricultural and industrial city of 30,000 inhabitants, situated 1861 meters above sea-level, and founded in 1575. It owes its name to hot springs found in the immediate neighborhood. This is a beautiful city, with numerous orchards and churches. Its peaceful inhabitants are devoted to agriculture and the arts. They are famous as weavers, and for the handiwork of the women, who come to offer their wares at the car-windows.

South of Aguascalientes, land of a better quality and well irrigated has favored the growth of a number of towns and cities. This region, up to the City of Mexico, is essentially agricultural, and constitutes the most densely populated part of the country.

About an hour after leaving Aguascalientes the traveler passes through the village of *Encarnación*, built on the rolling arid hills between the windings of a river, which the Mexican Central crosses by a magnificent iron bridge, sustained by two strong columns 65 meters in height.

Lagos.—This town, the county-seat of one of the districts of the large State of Jalisco, is 1915 meters above sea-level; has an excellent climate and 15,000 industrious inhabitants; and was founded by Francisco Martel in 1563, with the purpose of facilitating the subjection of the Chichimeca Indians, who inhabited that region. It has also a famous church.

León.—This, the second city of the State of Guanajuato, very important for its industries and commerce, situated at the foot of the valley, surrounded by hills and rocky plateaus, was founded in 1576, during the reign of Philip II. of Spain. The population, which is 60,000 to-day, has been, in prosperous times, as large as 100,000. In 1888 a terrible inundation destroyed the greater part of the city, and more than 200 persons lost their lives, while more than 20,000 were made homeless. A national subscription and the honorable efforts of the inhabitants have resulted in the reconstruction of the greater part of the town. The tanneries of this city are the most famous in the country, furnishing especially the leather for Mexican saddles and the traditional "charro" suits.

León is situated in the extreme northwest of a region specially favorable for the cultivation of cereals, by reason not only of its rich soil, of a porous volcanic formation, but also of the remarkable regularity of the rains, giving an opportunity to take advantage, for irrigation, of the waters of the important Lerma river, and some other water-reservoirs.

This region, shaped like a pail or wooden bowl, and bristling with mountains and volcanic hills, bears the name of *Bajío*, and was called in times past the granary of the central part of Mexico. The southern limit of the *Bajío* proper extends to the city of Querétaro; that is to say, it has a length of nearly 150

kilom., bounded by strips of rhyolitic plateaus or high mountains, such as the Guanajuato range on the east and the Pénjamo on the west. This is the most densely populated region of the Republic. Its numerous plantations, villages, towns and cities, connected by excellent roads, together with the railroad, give the *Bajío* a commercial and agricultural importance not realized in any other part of the country.

Silao de la Victoria.—After a ride of two hours through rocky table-lands, bounding the fertile plains, which widen gradually, this beautiful city is reached, almost at the foot of the Guanajuato range, celebrated in the annals of the country for the wonderful richness of its veins, which have been worked since the remote days of the Conquest. This town, 1860 meters above sea-level, and now possessing 15,000 inhabitants, was at the beginning a miserable village of Chichimeca Indians, first known by Nuño de Guzmán. About 1553 various Spanish families settled there, and gave to the place the name of a plant called *Silao*, which grows abundantly in the vicinity. The later name of Silao de la Victoria was given on account of a bloody combat between the armed Liberals and the revolutionary armies of General Miramón. The city is noted for the regularity of its streets, the cleanliness and simplicity of its houses, its ample public squares and its beautiful parish church, constructed in the 18th century. Hot springs are found near the town and on the slopes of the Guanajuato range. From the railway station the peak of *El Cubilete* towers to a height of 2560 meters above sea-level. A branch of the Mexican Central brings the traveler in two hours to the station of Marfil, above the open cañon which ends at the city of Guanajuato.

Irapuato.—This old town, founded in 1547 by an edict of Charles V., is noted for its active commerce, its hand-weaving industry, and the beauty of the exterior of its temples. In 1812 it was attacked by the insurgents and almost completely destroyed. In its innumerable orchards are cultivated with special care the strawberries which are principally consumed in the City of Mexico. These orchards are irrigated by water drawn from shallow pools by means of primitive well-sweeps.

Salamanca.—This town is in the center of the *Bajío*, on the right bank of the Lerma river, on the broad, low and fertile plain of black volcanic soil which becomes inundated during

the rainy season, forming in some places extensive swamps. It has fine churches, and the ruins of an ancient convent; and its inhabitants are industrious and skillful agriculturists. A street-railway connects it with the city of *Valle de Santiago*, a fertile valley surrounded by extensive, crater-like lakes, called *ollas* (earthen pots). *Valle de Santiago* is noted for its specialty of *rebozo* weaving.

Celaya.—This is one of the largest cities of the *Bajío*, being next in importance to *Querétaro* and *León.* It is situated on a plain at an altitude of 1810 meters; was founded in 1570, and was peopled at first by *Vizcainos*, who gave it the *Vasco* name of *Zalaya;* that is to say, "Plain-land." The first inhabitants had bloody encounters with the Chichimeca Indians, whom they succeeded in conquering. After that, the population increased rapidly, and has been energetically devoted to the cultivation of the land, which has been gradually irrigated by the waters of the Laja river, running near the city. Magnificent plantations, covered with *huizaches*, *mesquites* and other trees, surround the city. It has a number of large buildings, among which is the Carmen church, the façade of which is of Corinthian style, a work of the famous native architect, Tresguerras, born in 1745. In the interior of this church some paintings by celebrated native artists are much admired. Like the other towns of the *Bajío* region, the inhabitants, besides being agriculturists, are devoted to the weaving industry. It was in this city that the title of Captain-General was conferred on Hidalgo, the initiator of the Independence, eleven days after the *grito de Dolores* (Dolores proclamation), when the insurgent army had already reached the number of 50,000 men. The two main railroads of Mexico, the Mexican Central and the National, cross each other at the edge of the city, each having its own station.

Querétaro.—This city, the capital of the State of the same name, situated at the southern limit of the *Bajío*, has 35,000 inhabitants. It is an ancient Tarascan city, was subject to the crown of Montezuma I. about 1445, and conquered in 1531 by Fernando de Tapia. In 1655, Philip IV. conceded to it the rank of a city. It can properly be called to-day the city of churches; as it has sixteen large ones, many of them containing fine works of art in sculpture, paintings and wood-carvings,

which, together with its cloth, blanket and *rebozo* industry, have made it famous in the past. Close to the city is the large Hercules cotton cloth factory, partly run by water-power furnished by a magnificent stone aqueduct. The railroad passes underneath one of its gigantic arches. The construction of this aqueduct was commenced in December, 1726. At present the factory employs 1500 operators.

Querétaro has suffered in recent years a notable decline and loss of its supremacy in its industries. About the middle of the past century it reached a population of 50,000 inhabitants. It has always been an important theatre of political affairs. Here were held the famous meetings which prepared the glorious Proclamation of Independence, and in which Doña Josefa Ortiz de Domínguez took an active part. It 1821 it was besieged and taken by the Independents under Iturbide. At Querétaro, in March, 1848, the treaty of peace between Mexico and the United States was signed. Finally, in July, 1867, the Archduke Maximilian, and his Generals, Mejía and Miramón, were executed on the hill of las Campanas, a few kilometers from the city—a proceeding which completed the downfall of the empire which Louis Napoleon had attempted to establish in Mexico.

San Juan del Río.—This is a small city, 2000 meters above sea-level, and surrounded by good plantations irrigated from the river. It was a center of traffic before the arrival of the railroad, and is still active in the commerce of cereals.

Tequixquiapan.—The plains and slopes are bounded by high mountains, such as the Galindo range on the west and the Santa Rosa to the southwest, at the base of which the town of *Tequixquiapan* is surrounded by large mesa-lands and hills, from which are extracted the famous Mexican opals, celebrated all over the world. The fertile and delightful valley is bounded on the north by the majestic peak of *Bernal*, a conical and almost inaccessible mountain, where the rough and extensive *Sierra Gorda* begins, through whose sinuosities and cañons of wild beauty rushes the Moctezuma river, emptying into the Gulf through the paradise of Tampico.

In crossing the region of *Arroyo Zarco*, the railroad has to overcome new obstacles presented by the ruggedness of the country, either fertile and irrigated, or uncultivated, arid and

rough, and sometimes presenting mountain-slopes covered with extensive forests, which furnish fuel, railroad-ties and lumber.

Tula.—Through numerous curves and tortuous trails the railroad reaches this city, the junction of the Pachuca branch, crossing the river of the same name. In the environments of the now decayed town, and on its hills covered with volcanic lava, are still found vestiges of one of the most ancient Toltec capitals, *Tollán*, of which the great priest and founder was the mysterious *Quetzalcoatl*, to whom are attributed magic powers, deep knowledge of truth, and the knowledge of the casting of metals and stone-cutting. We are told that the city already flourished about 800 A.D. The present parochial church of Tula was constructed in the seventeenth century. Its turreted walls give it the appearance of a fortress.

The railroad follows the meanderings of the Tula, or winds through hills covered with lava (which in some places shows columnar structures) until it again reaches the plain on leaving the station of *El Salto*. To the right is the Cuautitlân river, flowing over a bed of lava, spongy stone and volcanic ashes coming out at the portentous, artificial cañon, master-work of Enrico Martínez, the *Tajo de Nochistongo*, justly admired by all travelers who can see it for a moment from the railroad, which runs along a few meters from the edge of the precipice built by the sweat of many Indians and the death of innumerable human victims, to save the City of Mexico from terrible and frequent inundations. That city is located in the interior of a vast basin, without outlet, into which descend the waters of the high mountains which surround it. These waters used to accumulate in large lakes with a very shallow average depth, and little higher than the average level of the city. On this account, frequent and terrible inundations resulted during the rainy season, and more than once almost completely destroyed the city.

Ever since 1580, radical measures have been suggested, from time to time, to save the city from such inundations. Indeed, in the time of the Indians, there existed dikes to retain the water, and retard its access to the old city of *Tenoxtitlán*. But in spite of these, any accident or washout was sufficient to cause alarm. From the beginning, it was intended to give an outlet to the waters of the north of the basin, which were the most

abundant, and which emptied into Zumpango lake—principally the waters of the Cuautitlán river.

This project was entertained for many years in an embryo form, until, at the beginning of the seventeenth century, another plan was submitted by the able cosmographer of unknown nationality, Enrico Martinez. His idea was to open a tunnel through the hills and slopes of *Nochistongo*. In this, work was commenced in 1607, during the reign of Viceroy D. Luis de Velasco, by the employment of innumerable hungry and naked Indians at miserable wages. The tunnel advanced 6600 *varas* in less than two years; so that in May, 1609, the Viceroy, visiting the works, saw the waters of the Cuautitlán river running over the bed of the Tula. It was necessary to wall the tunnel with stone, and to make many repairs, to prevent or remedy its frequent obstruction. The plan was, in consequence, almost abandoned. About 1616, work was resumed upon it, but was shortly afterwards again suspended until 1625. In 1629 the tunnel was again cleaned out, and once more choked by the waters of Zumpango lake, overflowing the city to a height of two meters, drowning 3000 persons, and compelling the emigration of 20,000 families. The city remained inundated until 1631. Philip IV. ordered the abandonment of the City of Mexico, and the rebuilding of it in a better location; but as the property was valued at that time at $50,000,000, it was finally decided not to abandon such valuable interests.

In 1637 began the transformation of the old tunnel into the great and wonderful canal, constructed by the labor of hundreds of thousands of Indians, which has left to posterity one of the most gigantic works created by man, and which confers deserved glory upon Enrico Martinez. The gratitude of the city has erected a modest but eloquent monument to his memory.

Huehuetoca.—At the railroad station of this town, the cañon of *Nochistongo* is only a few feet lower than the average level of the land; the sombreness of the landscape gives evidence of the poverty of the soil, limy in parts, volcanic in others; but further on it changes quickly in the surroundings of Cuautitlán, a village which, like Huehuetoca, is in a complete state of ruin and decadence. They were lively towns before

the railroad took from them the extraordinary traffic of the wagon-road which crosses them, and placed the City of Mexico in close communication with the interior cities of the Republic. This wagon-road appeared like a serpent of dust, and was remarkable in those days for the continuous traffic of carts, carriages, and all kinds of vehicles, pedestrians, companies of soldiers and bandits. To-day, destroyed, uncertain, and full of stones, it serves as a path to a few *burros*, patiently guided by their masters, and transporting fruits and other products of the neighboring towns.

Tepotzotlán.—This small town, a few kilometers from Cuautitlán, at the foot of the high hills which bound the horizon west of the railroad, has a magnificent convent and church, erected by the Jesuits before their first expulsion, and particularly noted for their beauty and good state of preservation, as well as for their curious, extravagant architecture, not only in the filigreed lines of a magnificent tower and façade, but also in the splendid gilding of the altars of the temple. In the cloisters and chapels of the convent are a multitude of paintings. Perhaps the wooden sculptures, including especially the carving of an organ, and a small set of chairs of rich and delicate design, are more to be admired. A small chapel, adjoining the church, shows the same curious, extravagant style of architecture, resembling, in its variety and richness of color and profusion of figures, the ancient orthodox churches of the City of Mexico. This place is deserving of attention, but, unfortunately, is seldom visited.

Lechería is reached a little further on, almost at the foot of the eastern slope of the Guadalupe range, which enters the valley of Mexico, interrupting the plain and appearing to divide the southern portion of the valley.

The railroad here has to ascend the first incline of the range and wind up the hills to reach the top of the *Cuesta de Barrientos* of the old cart-road, from which can be admired the magnificent profiles and sinuous heights bounding the valley of Mexico, and the extensive forests and vast fields of corn at the bottom of the valley, interspersed with groups of trees, among which, half-concealed, are grouped the small villages over which tower high white spires.

Finally there may be discovered in the distance Chapultepec

hill, with its castle, and at one side the massive black towers of the Cathedral and the blocks of houses, like walls of stone, which mark the site of the City of Mexico, the ancient capital of the vast Mexican Empire.

The Patio Process for Amalgamation of Silver-Ores.

BY MANUEL VALERIO ORTEGA, CITY OF MEXICO.

(Mexican Meeting, November, 1901.)

INTRODUCTION.

THIS Mexican amalgamation-process, invented in 1557, at Pachuca, by Bartólomé de Medina, has been widely discussed in America and Europe, but thus far there is no universal agreement as to all the chemical reactions involved.

Having been, after many trials, the first to succeed in effecting the amalgamation of silver-ores by the same mechanical means, but doing without one of the chemical substances which had been considered indispensable in the practice of 300 years, I am led to offer these notes as a contribution to the discovery of an exact theory concerning the *patio* process.

My treatment for silver- and gold-ores being protected by letters-patent in this country, the United States, France, Peru, Bolivia and Chile, I may speak freely concerning its materials and manipulation.

I. PATIO-AMALGAMATION.

The ore extracted from the mine is sorted by *pepenadores*, who break the large pieces with hammers, rejecting those which contain no ore, set aside the very rich to be smelted, and deliver the rest to be crushed and pulverized for direct amalgamation in the *patio*. The broken lumps, of about fist-size, are first ground in Chilean mills, and then reduced, in *arrastras* or *tahonas*, to fine slime.

After the *lama* or slime has acquired a suitable consistency by the evaporation, through the sun's heat, of a part of the water which it contained, it is spread upon the *patio* or amalgamating-floor, where it is mixed with 5 or 6 per cent. of common salt. The next day a certain amount (depending upon

the nature of the ore and the season of the year) of bluestone (cupric sulphate) is added; and, immediately afterwards, mercury, in the proportion of eight units to one of silver contained in the mineral, squeezed through a piece of thick cloth or chamois skin, and spread over the pulp or *torta*. These chemicals are thoroughly mixed with the slime by means of horses or mules trampling the *torta*—an operation called the *repaso*, and repeated daily until the treatment is finished. The time required is from two to five weeks, depending upon the quality of the ore, the temperature of the locality, and the period of the year.

Samples are taken at intervals for assay by washing in a vanning-bowl; and when the tests show that amalgamation is too slow, more bluestone is added; if it be too active (from the presence of copper sulphate in excess, as indicated by gray color and floured mercury), it is retarded by the introduction of lime, cement-copper or wood-ashes. At the end of the process, it is usual in some places to make a final considerable addition of mercury, in order to collect the grains of amalgam.

Amalgamation being finished, the *torta* is transferred to deep circular stone vats, or settlers, through which water is passing, agitated by a revolving paddle. The amalgam and other heavy metalliferous materials collect in the bottom, while the light, earthy impurities are held in suspension and carried away.

The fluid amalgam thus obtained is squeezed through canvas bags, whereby the excess of mercury is forced out, and there remains a solid or pasty argentiferous amalgam, containing about one-fifth of its weight of silver. This is compressed into triangular segments, which are transferred to the *quemaderas*, or retorting-houses, for the separation of the mercury by heat.

II. Chemical Theory of the Patio Process.

Prof. Greenwood, in his *Manual of Metallurgy*, says the chemical reactions in the *patio* are not well understood, but

"The first object is to convert the argentic sulphide (Ag_2S) into chloride, effected by exposing a mixture of argentic sulphide and common salt to the action of air and moisture, as in the first stage of the process, when an amount of argentic chloride is produced; and again, on the addition of *magistral*, the active constituents of which are cuprous [cupric] sulphate and ferrous sulphates, double decomposition ensues, with a rise of temperature and the production of cupric chloride ($CuCl_2$) and sodic sulphate, thus—

$$CuO,SO_3 + 2NaCl = CuCl_2 + Na_2O,SO_3;$$

while the cupric chloride so produced, in the presence of cuprous [cupric] sulphate and sodic chloride,* converts argentic sulphide into chloride, probably in the following manner—

$$Ag_2S + 2CuCl_2 = 2AgCl + Cu_2Cl_2 + S;$$

while the resulting cuprous chloride (Cu_2Cl_2), together with a further proportion, probably formed by the reaction of silver upon cupric chloride, thus—

$$2CuCl_2 + 2Ag = 2AgCl + Cu_2Cl_2,$$

in the presence of air and sodic chloride, reacts upon a further portion of argentic sulphide, with the production of argentic chloride and a greenish-white residue of oxychloride of copper,

$$2Ag_2S + 4Cu_2Cl_2 + 6O = 4AgCl + 2\,(CuCl_2 + 3CuO) + 2S.$$

"The argentic chloride formed, as the result of these reactions between argentic sulphide, sodic chloride and cupric chloride from the *magistral* is then acted upon by the mercury added for the amalgamation with the production of mercurous chloride (Hg_2Cl_2) and metallic silver, which amalgamates with the excess of mercury present—"

$$2AgCl + 3Hg = Hg_2Cl_2 + Ag_2Hg.$$

Let us examine this theory. The author says the object of the salt is, in the first place, to convert the argentic sulphide into chloride, and then to form cupric chloride, in order to continue the same operation.

I do not see the necessity of adding bluestone, if the chlorination of the silver can be affected with salt alone; and since, in practice, so far as I know, argentic sulphides are never treated with salt alone, I think we may at once reject that idea.

That chloride of sodium and cupric sulphate form by mutual decomposition cupric chloride and sodic sulphate is true; but that this cupric chloride, under the conditions of the treatment, will convert the sulphide of silver into chloride, I certainly deny. When cupric chloride acts directly on the artificial sulphide, in the absence of other substances, such reaction does take place; but the experiments of Karsten and Boussingault prove that, in the practice of the *patio*, it does not occur. This is further shown by the following experiment cited by Mr. Uslar in his *Ensaye sobre la Amalgamacion en Toneles:*

* Permit me to ask, Under what law is only part, and not all, of the cupric sulphate converted into chloride?

"To a certain amount of ground ore there was added twice the ordinary quantity of salt. Eight days after, the necessary *magistral* (burned iron and copper pyrites, frequently used instead of bluestone) was mixed, and the treading of the pulp was continued for fifteen days more, when metallic iron was added and the treading prolonged for two days. Then the mercury was mixed; but there appeared no signs of amalgamation; and after eight days the whole thing was washed out, and the mercury came out without any silver. So, then, it is untrue that, by the united action of the salt and cupric sulphate, silver chloride is produced, which is reduced by the mercury; because it ought to be formed with the quantities of chemicals used; by the iron it ought to be reduced quicker than by the mercury; and there should not have been any *consumido*—that is, loss of quicksilver by chemical change; but nothing of the kind occurred."

In our theory, we accept the first of Mr. Greenwood's reactions,

$$2NaCl + CuO,SO_3 = Na_2O,SO_3 + CuCl_2,$$

but not the second.

What, then, is the object of the cupric chloride? In my opinion it acts on the mercury, converting it into mercurous chloride (calomel), itself becoming cuprous chloride—

$$CuCl_2 + Hg = CuCl + HgCl.$$

Mr. Fernandez, in his *Teoria del Beneficio*, says:

"When in the solution of salt and bluestone that we are studying we add a certain quantity of mercury and the liquid is shaken, there appear two kinds of precipitates, both white; but the first one is heavy, and the other floats for a long while; the one is blackened by ammonia, and the other is dissolved at last, and imparts a blue color to the ammonia. At the same time the mercury is subdivided and becomes gray, and sometimes black; if it is washed and rubbed hard, it separates the same white, heavy substance that we have mentioned; this is nothing but calomel, and the other is pure cuprous chloride."

Not all the cupric chloride formed is converted into cuprous chloride; for the reaction can take place only by direct contact, and the volume of mercury is very small, compared with that of the pulp. Moreover, the solution of cupric chloride is weak; supposing that for each ton of ground ore containing 700 kilos of water, 3 kilos of bluestone were used, the cupric solution would not be over 0.5 per cent. in strength.

On the other hand, the accident known in practice as *calentura*, which is recognized by the rapid formation of mercurous chloride, is due to an excess of cupric sulphate; whereas, if the cupric chloride formed by it acted on the silver sulphide, the effect would be only to hasten the amalgamation, without injuring the quicksilver at all.

Again, it is well known that when horn-silver is submitted to the *patio* process it encounters the same accident, owing to the stronger affinity of chlorine than of silver for mercury; and if such a thing happens to the combination of silver and chlorine already made, how can we admit that the cupric chloride will act on the argentic sulphide in proportion to metallic mercury?

According to my theory, the second reaction must be this:

$$CuCl_2 + Hg = CuCl + HgCl.$$

Assuming that this is the case, the question arises, Does the cuprous chloride chloridize the argentic sulphide? By no means. Domeyko says:

> "Cuprous chloride, either in powder or dissolved, reduces silver sulphide with the production of cupric chloride, native silver and cuprous sulphide."

As this was the last resource left to the defenders of the theory of chlorination on the *patio*, we may conclude that chlorination does not occur; but, to give more value to this conclusion, I will mention some other proofs.

1. The conversion of argentic sulphide into chloride is not necessary. It is intended to facilitate the reduction of the silver by the mercury; but this is more easily accomplished (under the same circumstances) with the sulphide alone. Malaguti and Durocher say:

> "The reduction of silver chloride by means of mercury is very slow, especially if there is no water present, while argentic sulphide is reduced even by mere contact."

2. Native chloride of silver (horn-silver) never has been treated successfully on the *patio*. This difficulty was the origin of the *caso* or caldron process, invented by Barba, in which, as is well known, the native silver chloride is reduced by the metallic copper of the apparatus, and not by the quicksilver. Yet, according to the theory we are analyzing, horn-silver ought to be the best ore for the *patio*, since nature has already provided in it the chemical combination attributed to the salt and bluestone of that process.

3. To show how difficult it is to treat artificial chloride of silver by the *patio*, I made the following test: In the lixiviation-

process, the ores are chloridized first, in order to extract the silver by a solution of sodium hyposulphite. I took a ton of ore so prepared, and worked it with mercury only, as the silver was already converted into chloride, and there was no need of chemicals to chloridize it. After a month's treatment there appeared no trace of amalgamation. I then added the usual amounts of salt and bluestone. There was an immediate change in the appearance of the mercury, which became coated with a gray, opaque film; but, notwithstanding this, it did not catch any silver; and when washed out, after two months' treatment, half the weight of the quicksilver had been lost, and the remainder contained very little—almost nothing—of silver.

4. If there were really, in the *patio*, a formation of chloride of silver, subsequently reduced by the mercury, the loss of mercury should be 1.85 times the weight of the silver obtained. This is not the case. In the majority of instances the total loss of quicksilver, including the inevitable waste in the several manipulations, is between 1.25 and 1.5 times the weight of silver obtained.

5. In the *caso*, as well as in the Freiberg barrel-process, where the ores contain silver in the state of chloride, either natural or artificial, the loss of mercury is very small, say from 5 to 10 per cent. of the silver, because in those processes the reduction of the chloride is effected by the metallic copper or iron; but when those metals have been tried on the *patio*, the result has been negative. In this respect Mr. Uslar says:

"The object of another series of experiments was to protect the quicksilver by means of metallic copper and iron, but the results were entirely different from what we expected. Where there was iron there was no amalgamation; a small quantity of copper seemed to do good, the loss of quicksilver being somewhat less; but the amalgam contained a certain amount of copper, and if the quantity of this metal was increased, the resulting amalgam contained no silver, but copper."

The explanation of all this is very clear. Probably the iron was added in excess, and all the cupric chloride was reduced; and, when copper in small quantity was used, some cuprous chloride was formed; but when copper was added in greater quantity, it amalgamated before the silver.

6. In the *tortas* under treatment there has never been found a single particle of chloride of silver, notwithstanding it has

been looked for with positive care. It can scarcely be argued that this is the result of the reduction of the argentic salt by the mercury; because immediate contact between the two is impossible, since the argentic chloride should be dissolved *in statu nascendi* in the brine with which all the mass is impregnated. There cannot be, therefore, an instantaneous and complete reduction by mercury to explain the observed absence of argentic chloride in the *torta*—which thus constitutes a strong argument against the formation of that salt in the *patio* process.

In 1887, while a student at the Columbia School of Mines, I published a pamphlet, entitled *Manual del Azoguero*, in which I tried (as some other authors had done) to explain the reactions of the *patio* by the formation of argentous chloride (Ag_2Cl); but I was convinced afterwards that, although such a salt exists, has been found native, and is (according to Bonant's *Diccionario de Quimica*) the basis of photography, it is insoluble in brine, and ammonia decomposes it into argentic chloride and a very small portion of metallic silver.

If silver, then, is not chloridized in any form, what is, then, the office of the cuprous chloride in the *patio* process?

Domeyko's answer has been quoted, to the effect that cuprous chloride reduces sulphide of silver with production of cupric chloride, native silver and cuprous sulphide. I agree with him regarding the production of metallic silver, which is the main purpose of the process, since that is the only condition in which amalgamation is possible. But more complex reactions here involved may require some changes in the simple formula representing the direct action of one substance upon another.

How does the cuprous chloride reduce the argentic sulphide? It is well known that all the cuprous salts absorb oxygen from the air, and unquestionably to such a property the reduction may be attributed. I will then set down the last reaction that, according to my theory, occurs in the *patio* process, namely:

$$CuCl + 4O + Hg + Ag_2S = CuCl + HgO,SO_3 + 2Ag.$$

In other words, the important function of the cuprous chloride is similar to that of nitrous acid in the manufacture of sulphuric acid, being only the conductor of oxygen absorbed from

the atmosphere, first to oxidize the mercury, and, secondly, to produce sulphuric acid with the sulphur of the argentic sulphide, leaving the silver in the nascent state to form amalgam with the excess of mercury.

At first sight it seems that the loss of quicksilver should be large if this reaction occurs; but that it is, in fact, much less than the so-called *consumido*, which is unit per unit, will appear from the two formulas corresponding to argentic sulphide and mercuric sulphate respectively:

$$Ag_2S = 87.09 \text{ Ag and } 12.91 \text{ S.}$$
$$HgO, SO_3 = 67.56 \text{ Hg; } 5.41 \text{ O; and } 27.03 \text{ } SO_3.$$

The oxidation of mercury explains perfectly the accident called *frio* in the amalgamation, which is characterized by the yellow and sometimes black color of the quicksilver,* as due to the insufficient strength of the cuprous solution to produce the sulphuric acid, with which the oxide of mercury must combine. This is the reason that amalgamation stops, and to remedy this defect more bluestone must be added.

It may be objected that mercuric sulphate never has been found in the *tortas;* but the reason is, that as soon as it is formed it is converted into mercurous chloride, on account of the excess of chloride of sodium present. It is well known that mercuric sulphate is sometimes employed to prepare calomel by the method of Haermstedt and Planché.

It may be further objected: If there is no chlorination of the silver, what is the use of such an enormous quantity of salt? I think the object of that strong solution of chloride of sodium is to dissolve the cuprous chloride to facilitate its oxidizing action. According to data published by Dr. Sterry Hunt, the solubility of this chloride in a solution of salt increases remarkably with the strength and temperature of the latter. Moreover, in the pan method very little salt is used. Mr. Eissler says:†

"Ten pounds of salt is put in each pan to treat half a ton of ore, at a temperature of 180° F., which quantity is about 20 per cent. of the salt used in the *patio* at the ordinary temperature."

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* The yellow oxide constitutes a variety somewhat different from the red oxide of mercury. See Bonant's *Diccionario de Quimica*, p. 219.

† *The Metallurgy of Silver*, p. 120.

It is on this account, also, that the *patio* treatment takes longer in winter than in summer, namely: the lower temperature diminishes the amount of cuprous chloride dissolved.

For direct proofs of my theory, I must again refer to my process of amalgamation, invented in 1893. In this system there is no chlorine used in any form. Srs. Don Carlos F. de Landero and Don Guillermo de Uslar, in May, 1893, certified as to the good results of this process, with reference to thirteen series of charges treated in barrels in the San Miguel de Regla reduction-works. In Sr. Uslar's report the following statement is made:

"Regarding the chemicals used, Sr. Ortega excludes salt (NaCl) entirely; and for this reason this process overthrows the opinion of some metallurgists, according to which amalgamation cannot take place without the application of chlorine."

The substance of which I avail myself to carry out the amalgamation, whether the silver is in the state of sulphide, chloride, or any other combination, is a hyposulphite of copper, which acts exactly in the same manner as the cuprous chloride, and is easily prepared at ordinary temperature, without the aid of mercury. For this reason, the loss of mercury is smaller than in the old process. Moreover, this salt is very energetic in its action, and hastens amalgamation in such a wonderful way that I have had *tortas* in the *patio* that I have treated in a single day, saving 95 per cent. of the assay value of ore.

My process has not been introduced or adopted in many places for two reasons: first, the well-known resistance always opposed to what is new; secondly, the natural reluctance of the proprietors of reduction-works to pay a small royalty for the use of a process, when, as they candidly say, they do not have to pay anything to Bartólomé de Medina. I must confess, however, that some establishments have employed all their resources to try my process. Often I have met with great difficulty from the reactions of the grinding-apparatus, when this has been made of iron instead of the best steel. In such cases, as may be easily guessed, the cuprous salt has been immediately decomposed by the metallic iron; and more chemicals have been necessarily used, making the process too expensive for profitable use. But this difficulty is not insurmountable; and I hope to overcome it very soon.

In places where the grinding of the ore is done in *arrastras*, my process has given splendid results. Since 1895 it has been used in the Proaño reduction-works, where more than 100 tons of ore, containing silver in the state of sulphide, are treated daily in the works of Messrs. Felipe Rodriguez and Bernardo Saldaña, at San Juan de Guadalupe, where only horn-silver is dealt with.

There are other places where this new process is employed, with or without my consent.

Notwithstanding such difficulties and drawbacks, I shall be satisfied if this paper shall convince its readers that there have been errors in the accepted theories of Mexican amalgamation, and if the twenty years which I have dedicated to these investigations shall prove useful at some future day to the mining industry in general, and especially to that of my own country.

Notes on the Structure of Ore-Bearing Veins in Mexico.

BY EDWARD HALSE, PUERTO BERRIO, COLOMBIA, SOUTH AMERICA.

(Mexican Meeting, November, 1901.)

NORMAL banded structure,* exhibiting bands or layers of mineral symmetrically arranged from the sides to the center of the vein, appears to be by no means common in the Republic of Mexico.

When the bands of quartz form interlocking crystals in the center ("comb-structure"), the evidence that the filling has taken place in an open space is complete. This also applies in the case of any mineral the fibers of which are perpendicular to the walls, and which presents here and there, in a central line, cavities or vugs lined with crystals (geodes); but it does not follow that the whole width of the banded vein represents that of the original open fissure. The opening and filling may have been slow and gradual processes, advancing

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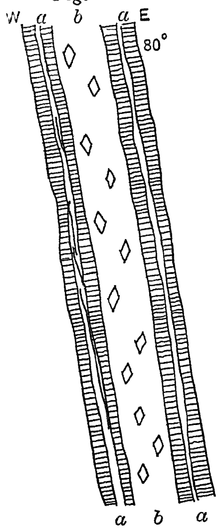
* Termed also veined, jointed or ribboned structure; French, *structure rubanée, zones concrétionnés parallèles;* German, *gebänderte Struktur* (or *Gefüge*); Spanish, *estructura bandeada, cinteada,* or *concreccionada*—the "crustification," in part, of Prof. Posepny.

simultaneously; or the fissure, having been once filled up with mineral layers, may have been re-opened and re-filled, along certain lines, with later minerals.

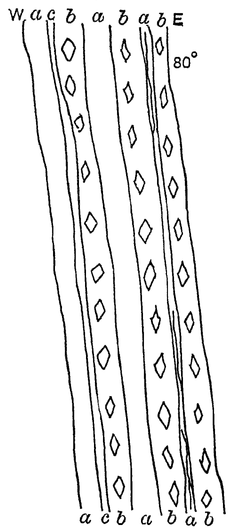
As examples of "simple symmetry" (Von Cotta), may be quoted certain portions of lodes in Cardiganshire, South Wales, where the filling from either wall to the center of the vein is successively blende—galena—quartz (the last exhibiting comb-structure); or, crystallized quartz—blende—galena—calcite; but, as Warrington W. Smyth* observed, the bands, as a rule,

Fig. 1



Gold- and Silver-Vein, 3 miles south of Zacatecas. Scale, 1 in. = 1 ft. *a*, Quartz with ribbony streaks of sulphides in center; *b*, Calcite.

Fig. 2



Same Vein as Fig. 1. Scale, 1 in. = 1 ft. *a*, Quartz; *b*, Calcite; *c*, Ribbony streaks of sulphides.

do not keep the same relative positions for long distances either vertically or horizontally.

Werner† long ago observed the following at Segen-Gottes, in Saxony, where normal banded structure is seen to great perfection, viz.: crystallized quartz, black blende with iron pyrites, galena, brown spar, galena, gray silver-ore (argentiferous fahlore?), ruby silver, argentite, calcite, so that the vein contains, in all, seventeen bands of mineral, symmetrically ar-

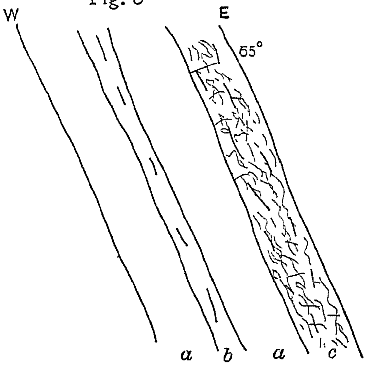
* "On the Mining District of Cardiganshire and Montgomeryshire," *Mem. Brit. Geol. Surv.*, Vol. ii., Part 2, page 655 (1848).

† *Neue Theorie von der Entstehung der Gänge*, Freiberg, 1791.

ranged from the sides to the center. He remarked that sometimes one or more of the different layers is wanting.

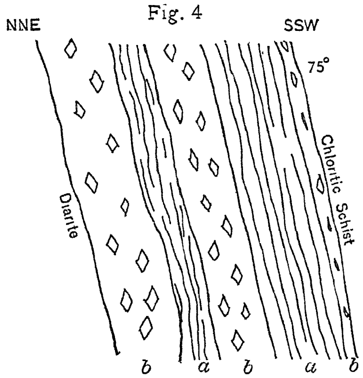
It is noteworthy that in both districts blende usually takes the inner side (*i.e.*, the side toward the center) of quartz; galena that of blende; and calcite that of galena; with the ex-

Fig. 3



Vein in the Neighborhood of Figs. 1 and 2. Scale, 1 in. = 4 ft.
a, Quartz with sulphides; *b*, Altered country-rock; *c*, Clay selvage.

Fig. 4

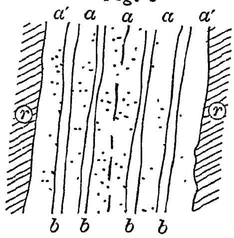


Vein Parallel to Fig. 3, at Depth of 90 ft. Scale, 1 in. = 4 ft.
a, Quartz with ribbony streaks of sulphides; *b*, Calcite.

ception that at Segen-Gottes silver-ores have been deposited between the two minerals last mentioned.

Fig. 1 shows the structure of a portion of a gold- and silver-bearing vein, about three miles south of the City of Zacatecas.

Fig. 5

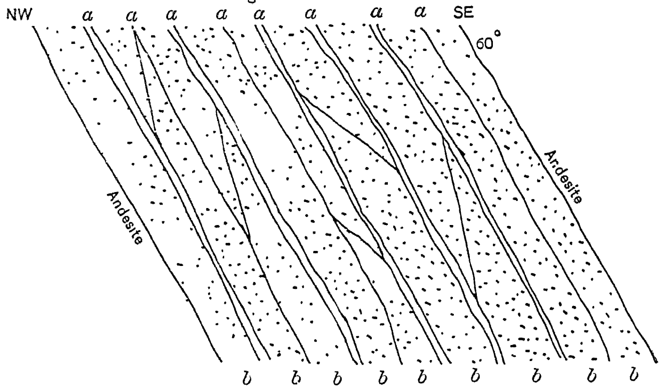


Same Vein as Fig. 4. Scale, 1 in. = 4 ft.
a, Bands of quartz and ore; *a′*, Ditto, becoming impoverished near the walls, *r*, *r*; *b*, Bands of pure quartz.

It looks like a case of simple symmetry; but the quartz, containing the ribbony bands of argentite and fine native gold, is crystalline, not crystallized; and the calcite, forming the center of the vein, although it has partially crystallized out in large imperfect rhombohedra, has no median line of geodes.

Fig. 2, from the same vein, shows three bands of quartz, alternating with three bands of calcite (thickness, 9 in.), the quartz forming the center of the vein. The remarks made

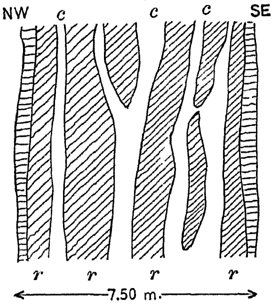
Fig. 6



Example of Banded Structure, Taviches Silver District, Oaxaca.
Scale, 1 in. = 4 ft.
a, Quartz-veins and stringers; *b*, Altered hornblende-andesite.

concerning Fig. 1 apply here also. Moreover, quartz lies on the foot-wall, while calcite lines the hanging-wall; and the gold is confined to the quartz. It appears as if the calcite were a

Fig. 7



Section of the Calicanto Vein, Pachuca, at Depth of 722 ft.
r, Pyroxene-andesite country-rock; *c*, Sterile white quartz. The selvages beyond *r* on both walls are crushed quartz and clay.

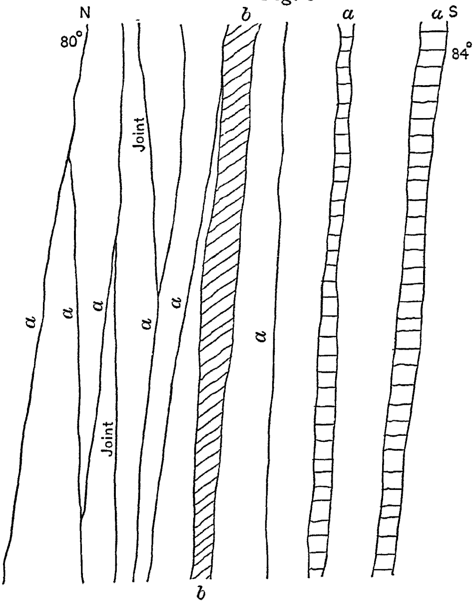
later filling, the result of the re-opening of the vein. The country-rock* seems to be a chloritic schist impregnated with iron pyrites.

* Prof. C. Le Neve Foster points out that to use the words country-rock is to be guilty of tautology (A Text-Book of Ore and Stone Mining, 1st. ed., p. 10). According to Courtney, *country* in Cornwall means ground; when the side of a

Fig. 3 represents the structure seen in a neighboring vein. Here two layers of gold- and silver-bearing quartz are separated by 6 in. of altered country-rock, while a thick clay selvage marks the hanging-wall. The opening of the central band of country, and its gradual substitution by calcite, would produce from this structure filling similar to that sketched in Fig. 1.

Fig. 4 is taken from a parallel vein at a depth of 90 ft.

Fig. 8



Banded Structure, Cardiganshire, South Wales.
Scale, 1 in. = 2 ft.

a, Quartz-veins and stringers; *b*, Quartz and galena. The white bands not lettered at the top represent country-rock. N and S at the top mean North and South.

Here calcite forms the center of the vein, and the same mineral lines the walls.

The evidence that a given banded structure has been produced by the re-opening of the vein is sometimes of a clearer nature. In Fig. 5* it would appear that the vein, after having

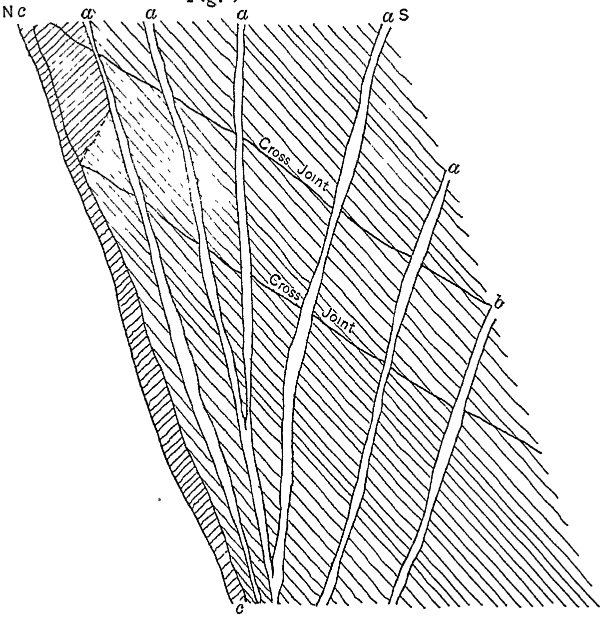
hill forms the back of a house, the latter is said to be built against the *country*. But the word is derived from the Latin, *contra*, over against; and surely we may use the term country-rock as meaning the rock against—or by the side of—the vein, in which sense it will correspond almost exactly with the German, *Nebengestein*.

* Taken from Fig. 2, page 61, of "El Mineral de Pachuca," *Bol. del Inst. Geol. de Mexico*, Nos. 7, 8 and 9, 1897. Compare with above Fig. 4 of the same work, where, the re-opening having been irregular, no banded structure has been produced.

been filled with quartz and argentiferous sulphides (*azogues*), was fissured or eroded in planes parallel to the walls; and that quartz, which is more hyaline than that of the rest of the filling, was subsequently deposited in the cracks.

An interesting example of six banded combs of quartz, produced by successive re-opening of the vein, was observed by De la Beche* in Cornwall, England. He says: "A close in-

Fig. 9



Banded Structure in Same Mine as Fig. 8.
Scale, 1 in. = 2 ft.

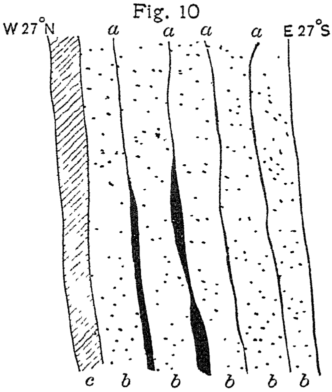
a, Quartz-veins, with a little galena and blende, here and there; *b*, Quartz, cerussite and galena; *c*, Quartz, with galena and blende. At the top, between *c* and *a*, a small mass of blende is indicated by shading contrary to that which represents the cleavage of the clay-slates of the country-rock vein-filling.

spection of the quartz crystals forming combs, by interlocking towards their central parts, often shows the gradual increase the crystals have received in the direction of. the axes of the prisms; and sometimes small sprigs of copper-ore or blende may be seen entangled among them, in lines corresponding with surfaces which existed during the formation of the comb,

* *Report on the Geology of Cornwall, Devon, and West Somerset.* See also James D. Dana's *Manual of Geology,* 4th ed., Fig. 309, p. 333. Other examples of banded structure are shown in Figs. 307 and 308 of the same book.

as if, while the crystallization of the quartz was effected, the siliceous solution sometimes contained the elements of the bisulphuret of copper, and was sometimes without them; or, if it

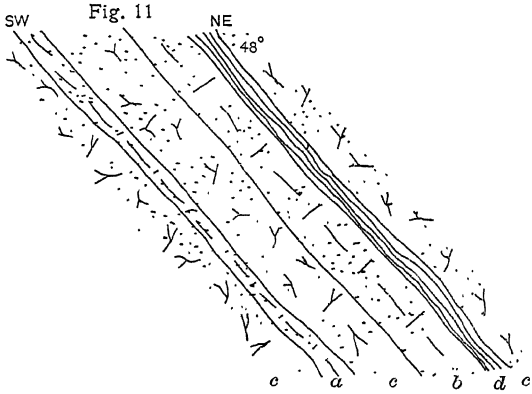
Fig. 10



Occurrence of Manganese-Ore near Mulejé, Lower California.
Scale, 1 in. = 4 ft.
a, Pyrolusite; *b*, Altered olivine-basalt; *c*, Pyrolusite with gypsum.

always contained them, that conditions were often unfavorable for their deposition on the sides of the cavity holding the solution."*

Fig. 11



Section of Silver-Vein near Matapé, Sonora, at Depth of 52 ft.
Scale, 1 in. = 4 ft.
a, Pay-streak; *b*, Quartz with sulphides; *c*, Altered granite; *d*, Clay selvage.

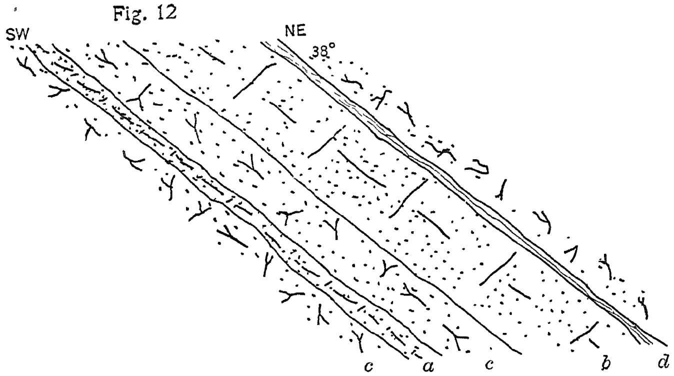
Banded structure sometimes appears to have been produced by the simple fissuring of the country, the fissures, at a later date, having become filled with one or more minerals.

* *Op. cit.*, pp. 341, 342.

Fig. 6 is an example from the Taviches silver-district of Oaxaca. A number of thin veins of quartz, parallel with the walls, are separated by hard hornblende-andesite.

Fig. 7* represents a section of the Calicanto vein, in Pachuca,

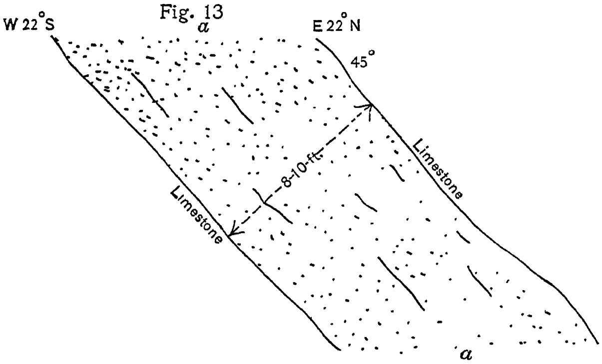
Fig. 12



Same Vein as Fig. 11, at Depth of 141 ft.
Scale, 1 in. = 4 ft.
a, Pay-streak; *b*, Quartz with sulphides; *c*, Altered granite; *d*, Clay selvage.

at a depth of 722 ft. (220 meters). Here the walls are marked by selvages of clay and crushed quartz; the country-rock is pyroxene-andesite; and the veins of quartz are fewer and wider than in Fig. 6.

Fig. 13



Section of San Augustin Vein, Tehuilotepec District, Guerrero, Mexico.
a, Limestone with stringers and spots of ore.

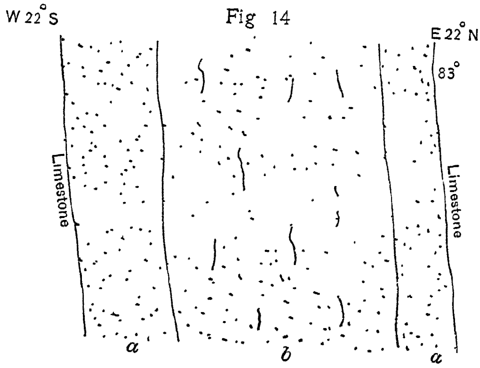
For the purposes of comparison, Figs. 8 and 9† are included, being instances carefully sketched by me in 1881–2, in a mine

* "El Mineral de Pachuca," Fig. 1, p. 59.

† Copied from Diagrams 1 and 3 of a paper published in *Rep. Roy. Cornwall Polyt. Soc.* for 1884. The remaining diagrams illustrate the same phenomena.

in Cardiganshire, S. Wales, at a depth of about 180 ft., and below water-level. A few joints are visible, which contain no quartz; moreover, there is a band of ore (galena, or galena and blende), as well as a slight mineralization of the rest of the

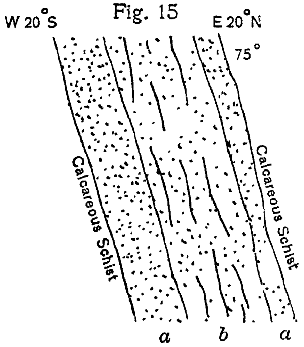
Fig 14



Remedios Vein, Same District as Fig. 13.
Scale, 1 in. = 4 ft.
a, Argentiferous marcasite, argentite, proustite, blende, and copper pyrites, in quartz and calcite; *b*, Limestone with stringers and spots of ore.

filling; hence a later phase in the history of the vein appears to be revealed. The main filling is metamorphosed clay-slate of Silurian age—the country-rock of the district. In Fig. 9 the quartz stringers have a radiated appearance, as if there

Fig. 15



Section of Ore-Vein of Pedregal Mine, near Tasco, Guerrero, Mexico.
Scale, 1 in. = 4 ft.
a, Blende, galena, proustite, argentite and quartz; *b*, Mineralized calcareous schist.

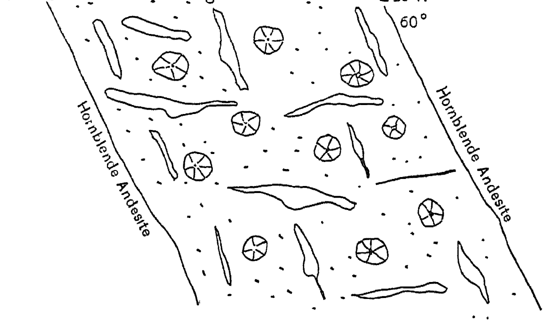
had been considerable local pressure acting obliquely on the foot-wall just below the section represented. The faint lines indicate cleavage-planes, which are visible in the surrounding formation. In other parts of the same vein "longitudinal

joints are the representatives of the crystalline quartz-veins of the harder portions of the lode." In none of the examples given in Figs. 6 to 9 would it appear that the country occupies a pre-existing cavity: it is evidently *in situ*.

Fig. 10 is an example of an occurrence of manganese-ore near Mulejé, Lower California. Olivine-basalt forms the country and, in this case, the main filling. Other veins in the same district show bands of quartz, gypsum, and pyrolusite, which appear to have replaced the eruptive rock.*

The most common type of banded structure is that produced by metasomatic processes in the country or in the vein itself.

Fig. 16



Same Vein as Fig. 15, Showing Complicated Structure, Due to Vesicular Country-rock.
Scale, 1 in. = 8 ft.

Quartz which has partially or wholly replaced schistose rock, frequently has a laminated or banded structure.

Examples of this, termed "ribbon-rock," are frequent in the Mother Lode of California. W. H. Storms,† referring to the Hite mine opened on the East lode, says:

> "A banded appearance of the quartz, probably induced in part, at least, by the original slaty structure of the rock, which has been replaced by silica, is very noticeable and persistent throughout the mine."

Figs. 11 and 12, from a silver-bearing vein near Matapé,

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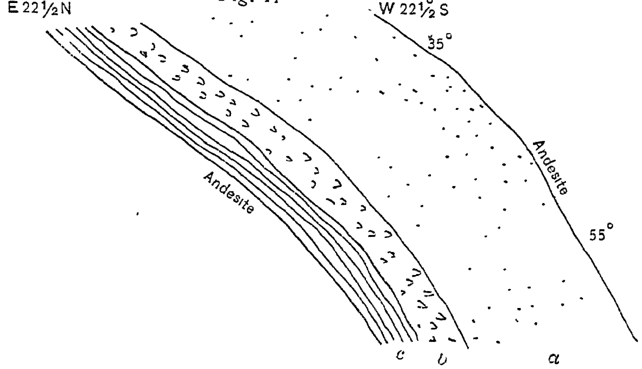
* *Trans. Fed. Inst. M. E.*, vol. iii., Plate LX., Figs. 2 and 3 (1891–2), of which Fig. 2 may be an instance of normal banded structure, as the filling from either wall to the center is crystallized gypsum, crystalline quartz and pyrolusite, with white concretionary sulphate of lime forming vugs; nevertheless, the vesicular nature of the rock must be taken into account.

† "California Mines and Minerals," San Francisco, 1899, p. 368.

Sonora, at a vertical depth of 52 and 141 ft., respectively, are examples of roughly-banded structure produced, probably, by the partial replacement of country-rock. The country is an

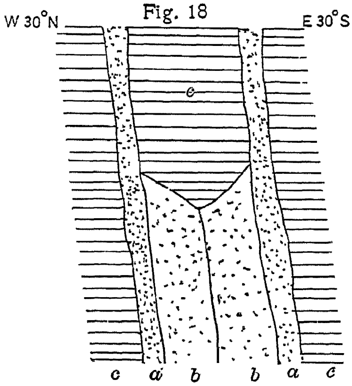
Fig. 17



Section of Vein on the Same Line of Fracture as Figs. 15 and 16.
Scale, 1 in. = 4 ft.
a, Quartz with scattered pyrargyrite, and some malachite and azurite; *b*, Quartz-rock; *c*, Red clay.

altered granite; and the ferruginous quartzose streak on the foot-wall in Fig. 11 appears in Fig. 12, below water-level, as quartz sprinkled with sulphides. Moreover, the clay selvage

Fig. 18



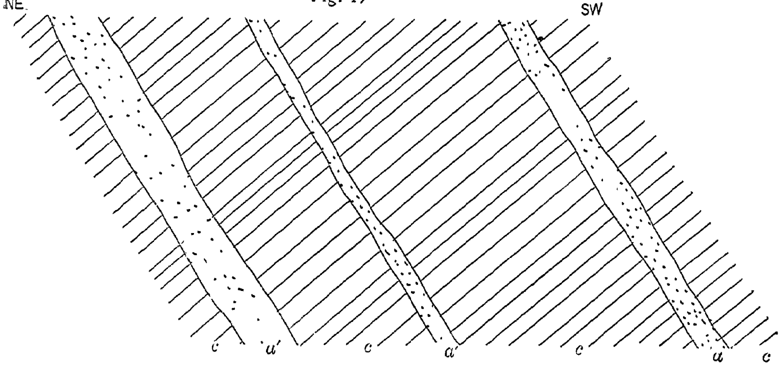
Replacement-Vein, in Santa Cruz de Alayá District, Sinaloa.
Scale, 1 in. = 4 ft.
a, Sulphides with quartz and calcite; *b*, Mineralized limestone; *c*, Cherty limestone in siliceous layers, crossing as shown.

on the hanging-wall is much thinner in Fig. 12, while the band of ore next to it has increased in width. The clay gouge may be regarded as evidence that considerable movement has taken

place on the hanging-wall side, whereby the granite immediately below was no doubt fissured and crushed, giving access to the mineral solutions which gradually replaced the crushed zone. The ore on the foot-wall side may have been formed at a different period.

Where the filling consists of porous rock, ore may occur in it in threads or stringers, or it may contain minerals scattered through it. Fig. 13 is an instance of the former type, observed in the San Augustin vein of the Tehuilotepec district, near Tasco, Guerrero, Mexico. The main filling is Cretaceous limestone, containing a good deal of calcite in large rhombohedral

Fig. 19



Another Vein in Same District as Fig. 18.
Scale, 1 in. = 4 ft.
a, High-grade ore; *a'*, Second-class ore; *c*, Cherty limestone in siliceous layers, dipping as shown.

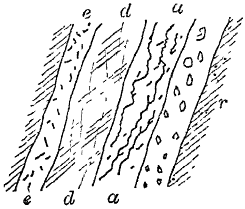
crystals. The ore consists of threads of fine-grained argentiferous galena; marcasite, with some chalcopyrite; blende, and crystals of proustite.

Examples of limestone filling with disseminated silver-ores have been observed by me in the district of Santa Cruz de Alayá, Sinaloa. More frequently, however, in such rocks, substitution appears to have taken place along one or both walls, producing a banded structure. Fig. 14 shows the structure of the Remedios vein, in the Tehuilotepec district. Here the limestone filling between the ore-bands contains scattered portions and some stringers of ore. In Fig. 15, from one vein of the Pedregal mine, near Tasco, calcareous schist forms the filling between the bands.

When the country-rock is vesicular, isolated patches and

spots of ore may occur. In the Taviches district, Oaxaca, already referred to, the andesite country not infrequently exhibits more or less rounded cavities. In one lode examined, these were filled with quartz which had crystallized out in a radiated spherical mass, a little piece (*mosca*) of pyrargyrite (*petlanque*

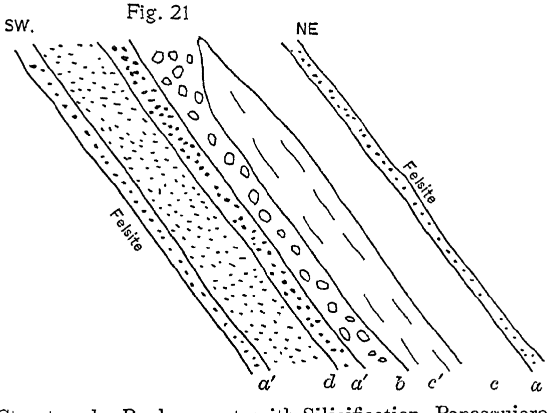
Fig. 20



Section of Maravillas Vein, Pachuca, at Depth of 328 feet.
r, Foot-wall, impregnated with ore; *a*, Ore with a little quartz; *d*, Calcite with quartz; *e*, Iron oxide and clay. Between *r* and *a* is a band of amethystine quartz.

oscuro) frequently forming the center.* The main filling is hard hornblende-andesite, with flat layers of calcite and hard red clay with disseminated small crystals of selenite. Threads

Fig. 21



Banded Structure by Replacement, with Silicification, Papasquiero District, Durango, Mexico. Scale, 1 in. = 4 ft.
a, Hanging-wall pay-streak; *a′*, Ore; *b*, Quartz-rock; *c*, Felsite; *d*, Quartzose felsite; *c′*, Felsite veined with quartz.

of quartz, expanding here and there to vugs, run parallel to the walls. In the same vein occur stibnite, calcite in large greenish rhombohedral crystals, and gypsum. Fig. 16 is an attempt to show this somewhat complicated structure.

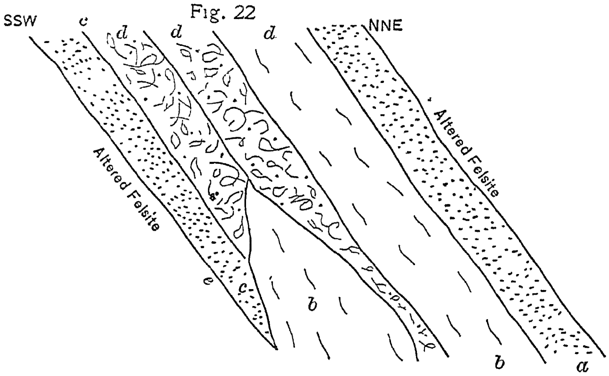
Fig. 17 shows a section of a vein on the same line of fracture.

* The structure of the vein would therefore appear to be amygdaloidal.

Hard andesite forms the hanging-wall, while on the foot-wall considerable kaolinization has occurred—the country being altered to a red clay; between the latter and the band of ore (quartz, with scattered *moscas* of pyrargyrite), silicification has converted the original andesite into quartz-rock.

Fig. 18 is another instance of a substitution-vein from the district of Santa Cruz de Alayá, Sinaloa. Two bands of ore are separated by limestone, containing numerous thin layers of chert of Crétaceous age. In the upper part of the section these layers are seen crossing a "horse" of country-rock; in the lower portion the cherty layers are not recognizable, since the limestone has been, to a certain extent, altered and mineralized.

Fig. 22



Banded Structure by Replacement, with Kaolinization, Same District as Fig. 21. Scale, 1 in. = 4 ft.
a, Pay-streak; *b*, Kaolinized felsite; *c*, Mineralized felsite; *d*, Clay; *e*, Clay parting.

Another vein (Fig. 19) in the same district is composed of three bands of ore, separated by limestone, having, like that of the surrounding formation, parallel siliceous layers, dipping in the opposite direction to that of the vein. The rock is unquestionably *in situ* in both cases.

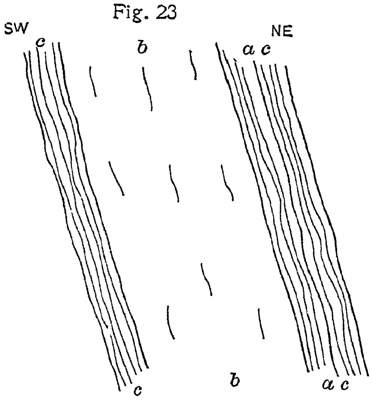
Banded structure may be produced by the building up of the vein from one wall only. Messrs. Aguilera and Ordoñez* appear to think that the structure, shown in Fig. 20, of the Maravillas vein, Pachuca, at a depth of 328 ft. (100 meters), was formed from the foot-wall side. At a short distance from where this section was observed, however, the amethystine quartz on the foot-wall was absent;† so that, in the former case, it may

* *El Mineral de Pachuca*, p. 63, Fig. 5. † *Op. cit.*, p. 62, Fig. 4.

have been formed by local substitution of the country-rock *after* the deposition of the two bands of ore.

Interesting examples of banded structure, produced by the partial replacement of the country-rock, have been observed by me in the district of Santiago Papasquiero, in Durango. Sometimes, as in Fig. 21, considerable silicification has taken place; or there may be much kaolinization, as in Fig. 22; or the same vein may exhibit both of these changes. The normal country-rock in this instance is felsite of the rhyolite group, having a well-marked flow-structure. The felsite occurs in interbedded or intrusive dikes, traversing quartz, hornblende-andesite, andesite-breccia, and porphyrite.

Fig. 23

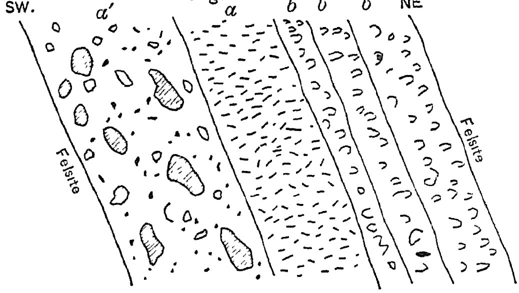


Section of Vein, Showing *Metal Caracol*, Papasquiero District, Durango, Mexico. Scale, 1 in. = 4 ft.
a, *Caracol* ore; *b*, Quartz-rock, with stringers of ore; *c*, Felsite with flow-structure.

A variety of silver-ore with a conchoidal structure, known as *metal caracol*, is common in the lode referred to. It often bears a close resemblance to the fluidal structure of the felsite country. Examined through a microscope, it is seen to be composed of a number of thin superimposed layers of quartz, some of which have blackish specks and stains, probably due to the presence of argentite; and there is little doubt that this ore has replaced felsite. Fig. 23 is one instance of its occurrence. It will be noticed that the rest of the vein—which may be described as a mineralized dike—has been altered to quartz-rock. In other parts of the same lode, *caracol* ore occurs between bands of ordinary quartz; so that re-opening, combined with replacement, may have produced the banded structure.

A brecciated structure is occasionally seen in the ore-bearing veins of Mexico. Fig. 24 was sketched in a working on the lode already referred to, in the district of Santiago Papasquiero. Rounded, as well as angular, white fragments of felsite, cemented by quartz spotted with ore, are seen on the foot-wall side of the vein. On the hanging-wall side are several layers

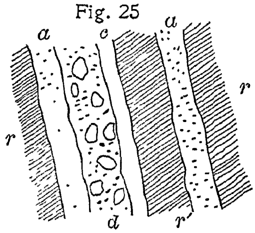
Fig. 24



Brecciated Structure, from Same Lode as Fig. 23. Scale, 1 in. = 4 ft.
a, Ore; *b*, Quartz-rock; *a′*, Brecciated filling (low-grade ore).

of quartz-rock, no doubt replacing the felsite country. In other portions of the same vein a similar structure is visible, either on or closely near the hanging-wall, inside the vein. Sometimes the foot-wall shows angular fragments of felsite or quartz-

Fig. 25



Section of Calicanto Vein, Pachuca.
a, Quartz with ferruginous oxides and black sulphides; *c*, Rib of pure quartz; *d*, Black-sulphide quartz, calcite, and fragments of country-rock; *r*, Country-rock; *r′*, Horse of country-rock.

rock embedded in red clay, forming an agglomerate rather than a true breccia. These observed phenomena may have been the result of local movement along one wall of the vein.

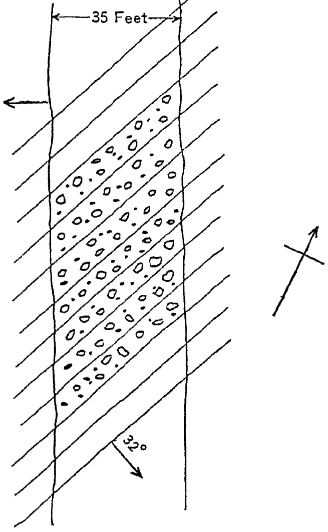
The Calicanto vein of Pachuca has, in one place, the structure sketched in Fig. 25.* The ore-streaks, *a a*, on the hanging- and foot-wall, consist of *colorados* and *negros* mixed; the center of the vein is occupied by a rib of pure quartz, *c*; between

* Copied from Fig. 7, p. 67, of "El Mineral de Pachuca."

this and the hanging-wall is a horse (*caballo*) of country-rock; and lying on the foot-wall band is a rib (*cinta*) of *negros*, quartz, calcite, and fragments of country-rock. The vein appears to have been re-opened along the center; and what has the appearance of brecciated structure may in reality be an instance of the partial replacement of the country; for, as a band of ore separates it from the foot-wall, it is difficult to conceive how it could have been produced by movement along that wall without leaving evidences of crushing in the band of ore also.

Sometimes the banded structure of veins is marked by cross-

Fig. 26



Plan of Structure in Taviches District, Oaxaca, Mexico.

joints, evidently of later origin than the vein-filling, and apparently indicative of recent horizontal thrusts in the country-rock. Fig. 26 is an interesting instance, observed by me in the Taviches district of Oaxaca. The joints "divide the vein up into a number of separate ribs, crosswise to the general strike, thereby more or less obliterating the original bands or ribs of quartz and ore parallel to the walls."* The ore in this case is pyrargyrite, occurring in spots (*moscas*) or little bunches (*ojos*), which are traceable across the vein in an oblique direction, and which pitch southward—*i.e.*, they follow the strike and dip of the cross-joints.

* "Some Silver-Bearing Veins of Mexico," *Trans.* (*Brit.*) *Inst. M. E.*, vol. xviii., 1900, p. 379.

Summary.

The contents of metalliferous veins are frequently irregular, or they show no definite structure; but they may exhibit the following characteristics, many of which have been referred to in this paper:

(1) Simple structure, or "alike in mineral or minerals from side to side." (James D. Dana.)

(2) Banded structure:

(A) Normal or symmetrical;* showing layers of mineral which have been deposited successively from both sides to the center of the vein, each corresponding pair of mineral bands having been deposited simultaneously.

(B) Unsymmetrical: (a) Exhibiting layers which have been deposited successively from one side of the vein to the opposite one. (b) With bands produced by the re-opening and refilling of the vein or country. (c) With bands produced by metasomatic processes, or by the partial or complete alteration, or substitution, of layers of mineral, or country, forming the original filling. The two latter may imitate (A).

(3) Brecciated structure, in which the filling consists of angular fragments of country, or older vein-matter, cemented by, or incrusted with, ore and veinstone.† In rare cases, where the rock or mineral is rounded, it becomes a conglomerate, and sometimes the filling is agglomeratic, consisting of angular or rounded fragments of country or mineral, lying more or less loosely in clay or other soft filling.

(4) Amygdaloidal‡ structure. This is rare; but it may occur in eruptive metalliferous dikes.

The term "crustification" is clearly unsuitable for banded structure produced either by re-opening or by substitution.

* "The fillings of ore-veins very often exhibit distinct crustification, and sometimes even a symmetric succession of crusts from both walls to the central druse." – Posepny, "The Genesis of Ore-Deposits," p. 70 (second edition, p. 77).

† "The fragments of rock, either angular or already more or less rounded, form, when incrusted, the so-called sphere-, cocarde-, or ring-ores. Crusted rock-kernels may often be observed co-existing with distinct wall-crusts. Sometimes the latter are less prominent than the former, and the ore-deposit then has the appearance of a breccia, or a conglomerate, the several fragments of which are held together by the mineral crusts."—"The Genesis of Ore-Deposits," p. 59 (second edition, p. 64).

‡ "Having the vesicles (which are often almond-shaped) filled with minerals foreign to the rock, such as quartz, calcite and the zeolites."—James D. Dana.

"Having cavities filled with alteration-products."—Granville A. J. Cole.

Mexican Railroads and the Mining Industry.

BY LUIS SALAZAR, C.E., MEXICO CITY.

(Mexican Meeting, November, 1901.)

[SECRETARY'S NOTE.—This paper, together with the valuable accompanying map, prepared by direction of Sr. Ingeniero Leandro Fernandez, Minister of the Department of *Fomento* of the Republic of Mexico, and presented in pamphlet form at one of the sessions of the Mexican meeting, is reprinted in full, although some portions of it may be found to repeat information contained in other papers.]

INTRODUCTION.

Internal improvements are the great seals; stamping upon the history of nations their epochs of peace, in which notable enterprises are conceived, and fresh impulses given along the path of progress.

Such forerunners of national benefits have never been so notable in Mexico as in the last four decades of the nineteenth century, during which the national faith in the consolidation of peace has been a guaranty of the development of all the elements of national prosperity.

Among all the improvements which have been realized with the unanimous approbation of the people, the railroads occupy a preferred place, for upon them depends the expansion of commerce, of agriculture and of mining, the three great factors of the wealth of Mexico.

In a country so extensive as the Mexican Republic, where the inhabitants are greatly scattered, and great distances separate the producer from the consumer, the only way to encourage home industry, and the development of commerce, agriculture and mining, is to construct railroads, which shorten distance, facilitate transportation and minimize its costs.

The mountainous character of the country makes the navigation of its rivers practically impossible, except very near to

the coasts; and experience has shown that well-made carriage-roads cost as much as a railroad, and are much more costly to maintain.

As a nation whose civilization is relatively recent, and whose traditional disturbances are well known, we encounter serious difficulties in obtaining the capital which is indispensable for the construction of railroads, especially in the first period of construction of the system; and this is the more felt when the work, once commenced, is very slow in its advance.

Each country, according to its economic conditions and to public opinion, has adopted the most appropriate manner of promoting the construction of railroads—in some cases, the direct and exclusive action of the Government; in others, private enterprise, the official concession of subventions, and franchises to syndicates or companies.

The first form of encouragement presupposes a perfect system of income and a flourishing state of the treasury, a perfect and efficient organization of the public administration, capable of rendering the service of its employees upon construction, maintenance and operation of a railroad, as effective as in the case of a private company. In Mexico, only the National railroad of Tehuantepec, and the branch from Tehuacan to Esperanza, have been constructed in this manner; and the latter was never operated by the Government, and is now private property.

The second form of assistance is impossible in Mexico, on account of the relative scarcity of capital and the total lack of the spirit of enterprise.

The policy which has been adopted, therefore, has consisted in subsidizing railroad enterprises with grants of money or bonds, and with liberal franchises.

Public prosperity and tranquillity depend, at least in part, upon the establishment of railroads. It is therefore natural that the Mexican Government, when it initiated, in 1877, an era of progress for the Republic, should have wished to enter at once into the enjoyment of these benefits by the extension of ample concessions, and giving satisfactory protection to the first contracts that were made. Hence useless formalities were suppressed, and whatever would facilitate the execution of the works was temporarily permitted, while all classes of difficul-

ties, especially as to the expropriation of property, were summarily removed. The Government was persuaded of the importance of securing to the companies first organized a substantial success, as an encouragement to future enterprises.

The number and liberality of the concessions given antagonized public opinion for a short time; since it was believed that the federal revenue would not be sufficient to satisfy the obligations that had been contracted with the construction-companies. But it was necessary to make a supreme effort, even to make sacrifices, rather than to lose the opportunity of gaining, by the investment of foreign capital in Mexico, the impulse which would bring prosperity. Peace had given new birth to public confidence, and awakened in foreign countries the desire to employ their capital for the development of the almost virgin soil of Mexico. It was clearly the duty of the Government to favor the enterprises that came to aid the working forces of the country.

Not all the companies were able to fulfill their obligations, and the Government was not obliged to confront any heavy liability at any one moment. The small success of some enterprises was due to their speculative and irresponsible character.

In spite of this, the results as obtained are highly satisfactory. Mexico may be proud of having constructed, in a short space of time, thousands of kilometers of railroads, which have already led to many other internal improvements. The Republic is as yet far from having a network of railroads which fulfills all its necessities and aspirations; but not many years will pass before the great interoceanic and intercontinental lines will be actually complete.

These railroads will powerfully serve to diminish the losses which the mining industry has suffered from the depreciation of silver, and to encourage the increase of production. It is well known that silver occupies the first place in the list of exports from this country, which must be the measure, in the long run, of its importations. The amounts represented by the depreciation of silver must be compensated by the decreased cost of production of that metal, which, in spite of everything, must continue to be the preponderating element of exchange in exterior commerce. The geological structure of Mexico makes silver one of its leading natural products. Moreover, as an

article of merchandise, it is one of the most appropriate for exportation, not being subject to damage in transport, and representing large value in little bulk, and thus specially suited to the conditions of commerce. Hence, all measures which tend, by favoring the increase of the production of silver, to counteract the deficiency caused by its loss in value, have been the object of distinguished attention on the part of the Government.

The following synopsis shows how the principal railroads have been established in Mexico, and also mentions a few secondary railroads, principally of interest to miners.

I. The Interoceanic Railroad of Tehuantepec.

It has always been considered of very great importance to have a communication between the Atlantic and the Pacific Oceans.

The route by way of Cape Horn, to afford communication between western Europe and the Pacific coast of America and to Asia, involves a long and perilous voyage. The United States of America, from their enormous commercial traffic, have been obliged to construct, before all else, the railroads that bring New York and the other principal Eastern ports into direct communication with San Francisco, California, and with other ports of the Pacific coast.

American capital also opened the route by way of Panama to railroad traffic, shortening notably the communication between the two extreme coasts.

Communication between the two oceans by way of Tehuantepec has always had its champions, commencing with Hernan Cortês, the conqueror of Mexico, who traversed and personally examined the Isthmus, and found it to be of such importance, from a geographical point of view, that he asked Charles V. to concede to him, in that region, extensive properties, comprising the Tarifa, La Venta and Chicapa plantations.

The advantages of the Tehuantepec interoceanic route over that of Panama are very great, from the geographical point of view as well as from that of commerce. The annexed map will show, in a general way, the geographical advantages of Tehuantepec for the commerce between the coasts of the United States, and even with respect to western Europe.

The route which presents the greatest advantages should be

that which is the nearest to what may be considered the route of the commerce of the world, which may be marked on the globe as between Hong-Kong and Yokohama on the Asiatic coast, across the Pacific Ocean, passing through San Francisco, across the United States to New York, thence across the Atlantic to Liverpool or Havre.

Of all the interoceanic lines, that of Tehuantepec approaches most nearly to the above route of traffic. In a right line, the distance between Tehuantepec and Panama is 1200 miles. When we examine a terrestrial globe, we see that the shortest route for a sailing-ship or for a steamer between the Oriental coast of Asia and any point on the Pacific coast of the American isthmuses passes very near to the coast of Tehuantepec; practically the shortest great circle from Panama to Hong-Kong passes near Tehuantepec and to the east of San Francisco. Even the shortest route from Panama to the Sandwich Islands will pass very near to the Isthmus of Tehuantepec. It will be at once seen that nearly the double of the distance mentioned will be needed if we cross at the Isthmus of Panama, especially for the traffic of the Pacific Ocean with the Gulf ports. On a smaller scale, the distance by way of Panama to all of the ports of the United States and of western Europe, on the Atlantic, will be considerably diminished by way of Tehuantepec.

The following table, formed from data compiled by the Hydrographic Office of Navigation, U. S. Navy Department, shows the distance between the commercial ports of the world, by way of the three American isthmuses, calculated in English miles:

Terminal Points.	Via Tehuantepec.	Via Nicaragua Canal.	Via Panama.
New York to San Francisco, .	4,925	5,651	6,107
New York to Puget Sound, . .	5,647	6,524	6,855
New York to Sitka, . . .	6,347	7,113	7,555
New York to Behring's Straits, .	7,788	8,524	9,101
New York to Acapulco, . .	2,722	3,507	3,988
New York to Mazatlán, . .	3,476	4,232	4,675
New York to Hong-Kong, . .	11,597	12,313	12,645
New York to Yokohama, . .	9,984	10,626	11,211
New York to Melbourne, . .	11,068	11,357	11,471
New York to Auckland, . .	9,345	9,747	9,813
New York to Honolulu, . .	6,566	7,390	7,075
New York to Callao, . . .	4,661	4,312	3,873
New York to Guayaquil, . .	4,141	3,774	3,303

Terminal Points.	Via Tehuantepec.	Via Nicaragua Canal.	Via Panama.
New York to Valparaiso, . .	6,370	5,774	5,337
New Orleans to San Francisco, .	3,561	4,776	5,415
New Orleans to Acapulco, . .	1,454	2,631	3,296
New Orleans to Mazatlán, . .	2,027	3,357	3,983
New Orleans to Callao, . .	3,393	3,436	3,181
New Orleans to Valparaiso, .	5,040	4,899	4,644
Liverpool to San Francisco, .	8,274	8,783	9,071
Liverpool to Acapulco, . .	6,076	6,639	6,952
Liverpool to Mazatlán, . .	6,714	7,364	7,640
Liverpool to Auckland, . .	12,584	12,877	12,777
Liverpool to Guayaquil, . .	7,379	6,848	6,267
Liverpool to Callao, . . .	7,899	7,444	6,837
Liverpool to Valparaiso, . .	9,356	8,906	8,301
Liverpool to Honolulu, . .	9,805	10,522	10,670
Liverpool to Yokohama, . .	13,223	13,758	14,175
Liverpool to Melbourne, . .	14,113	14,499	14,435

A comparison among sixteen of the principal routes of commerce between the Orient and Occident shows an aggregate saving of more than 125,000 miles by way of Tehuantepec.

The nautical conditions for sailing-ships are much more favorable at Tehuantepec than at Panama. Navigators always avoid, as much as possible, the region of calms on both sides of the Isthmus of Panama. According to the data of Lieutenant Maury and Captain Bent, well-known nautical experts, these calms extend to a great distance in the Pacific Ocean at the latitude of Panama.

It thus appears that an interoceanic route by Tehuantepec would connect the eastern and western coasts of the United States at the best possible place, and would develop a coasting traffic of great magnitude and of vast importance to the two countries.

The climatic conditions are very favorable in Tehuantepec. The prevailing winds from the northeast of the United States, which cross the Gulf of Mexico, make the climate of Tehuantepec very healthy.

These considerations have caused the Mexican Government to pay special attention to the establishment of the Tehuantepec railroad, seeking the solution of the problem even by great sacrifices.

The first contract for the concession of this interoceanic line was made in 1842, with Mr. José de Garay, who, being un-

able to undertake the work on his own account, turned over the concession to the United States Government, without authorization to do so from the Mexican Government: for which reason the concession was declared null and void.

Other contracts followed, all without result, either through the lack of funds by the contractors or because the construction of the Panama railroad impaired the financial prospects of the scheme.

It was not until 1879 that the first effective contract was made with Mr. Ed. Learned; but the company which he organized could only construct 35 kilometers of the road; and the contract was canceled when the several stipulated terms had expired, after having been extended several times. The section of railroad already constructed, as well as the rest of the property of the company, became the property of the Government for a cash payment of $125,000 silver, and a further sum of $1,500,000 U. S. gold, paid in several instalments.

The Federal Executive having been authorized by the Congress to construct the Interoceanic railroad of Tehuantepec for account of the nation, whether by direct administration or by contract, a commission of engineers was appointed to make the reconnaissance and location of the line, and $600,000 was sent to England and to the United States for the purchase of instruments, machinery, tools, implements, and rolling-stock.

After this, bids were asked for the contracting of the work; and from among the various propositions presented, that of Sr. D. Sánchez was accepted. This gentleman contracted in 1882 to do the work for the sum of $25,000 per kilometer of constructed railroad, taking over for his own account and risk all the sums spent up to that time by the Government, amounting to $701,000. Under this contract only 108 kilometers were constructed, in two divisions; but the railroad was not finished; and in 1888 the contract was rescinded, the Government having to make an outlay of $1,434,000 in payment for the materials that had been collected, for the work done, and for indemnification to the contractor.

For the completion of the railroad, the ordinary resources of the federal treasury were not sufficient; and it was necessary to obtain money in some foreign market by means of a loan. This loan was issued in London, Berlin and Amsterdam,

for £2,700,000, at 5 per cent. interest, with a mortgage on the railroad itself, placing the bonds at 70 per cent. of their par value.

The total product of this loan was destined for the completion of the line according to a contract made for that purpose, in London, with the house of MacMurdo, in 1888, according to which the work was to be terminated within two years and a half. But the death of Mr. MacMurdo made the rescission of this contract a necessity; and a new contract for the construction was entered into, in 1891, with Messrs. Charles Stanhope, J. H. Hampson and E. L. Corthell, for the conclusion of the work, applying for this purpose $2,000,000 remaining from the loan just mentioned, and under which 250 kilometers of railroad were constructed. The above amount was not sufficient; and some $3,000,000, from another loan made in Mexico, was assigned to the completion of the railroad.

Under a new contract made with Mr. Charles Stanhope, the line, with a total length of 309 kilom., was finished October 15, 1894. But the operation of the railroad made necessary the acquirement of an equipment which the Government was not in a condition to buy for cash. This was the motive for accepting propositions made to the Government in 1896, looking towards providing the line with rolling-stock and other things necessary for its service, and for the maintenance and operation of the line. The payment was to be made in successive portions, with a moderate interest on the unpaid sums.

The operation of the railroad and the maintenance of way was superintended, up to December 15, 1899, by officials appointed by the Government.

The mortgage of the Tehuantepec railroad and its dependencies, constituted to cover the loan of £2,700,000 just mentioned, was lifted when the conversion was made of the foreign debt at 6 per cent., in which were included all the mortgage bonds that had been issued.

On and after December 15, 1899, a company formed by Messrs. S. Pearson & Son, Ltd., of London, took charge of the reconstruction, maintenance and operation of the line, under the character of agent and representative of the Government. In a separate contract is included the contract for the engineering work in the terminal ports of Salina Cruz on the Pa-

cific side and Coatzacoalcos on the Gulf of Mexico, the principal parts of which will be finished in the four first years, and the whole within seven years.

The Federal Government and the company named have entered into a partnership-contract for the operation of the railroad and of the ports mentioned for the term of fifty years.

The efforts of the Mexican Government have been constant and unremitting, and its sacrifices very great; but it has at last realized the construction of a railroad of incalculable importance to the world's commerce.

II. The Mexican Railroad, from Mexico City to Vera Cruz.

As far back as 1837, the first decree was published for the construction of the railroad which was to unite the Capital with the principal Mexican seaport on the Gulf coast. Practically nothing was done by the successive companies owning the concessions relating to this road, until, in 1863, under the contract made with Mr. Antonio Escandon, 75 kilom. were constructed, from Vera Cruz to Paso del Macho.

The contract was transferred in 1864 to the English company which still retains the management of the business. In 1868 a section of 139 kilom., from the Capital of Mexico to Apizaco, was in operation; and the Puebla branch, covering 47 kilometers more, was inaugurated on December 16, 1869. The years of 1871 and 1872 were those of the greatest activity in the construction of the Mexican railroad; and finally, on January 1, 1873, the whole road was inaugurated. It may be well considered a great work, on account of its engineering constructions and of its daring location.

The total length of the system is 423.759 kilom. The principal engineering works are: The Soledad bridge, 228 meters long; the Paso del Macho bridge, 50 meters long; the San Alejo bridge, 97 meters long; the Chiquihuite bridge, 126 meters long; the Atoyac bridge, 100 meters long; the curved bridge of Rioseco, 75 meters long; and the famous Metlac bridge, also on a curve, 138 meters long and 28 meters high. The viaducts of the Infiernillo, of Wimer, and the Joya, are respectively 93, 85 and 91 meters in length.

At Vera Cruz this railroad has a steel wharf 200 meters long, with five hydraulic cranes of great power, which facilitate the

unloading of heavy merchandise and machinery. This wharf cost $150,000. The railroad has also in its service three steam towboats and thirteen lighters, with a capacity of 19 tons each, for the wharf-service.

This road may be considered as divided into three great sections.

The section of the central plateau between Mexico City and Boca del Monte has a length of 251.250 kilom. In this part the curves are of ample radius, and the maximum grade is 1.5 per cent. The greatest altitude of the line is in this section, where it has an elevation above sea level of 2532 meters. This section has 53 iron bridges, 34 culverts with stone arches, and 262 open culverts. The stations are 16 in number, of which 3 are of importance, namely, Mexico, Apizaco and Esperanza.

The second section, from Boca del Monte to Paso del Macho, measures 96.500 kilometers, over exceedingly broken ground, and comprises the summits of Maltrata, the Metlac gulch and the Chiquihuite gulch.

The curves are abrupt, and the grades are as high as 4 per cent. in several places, whose united length is 22 kilometers, while grades of from 2 to 3½ per cent. exist along 40 kilometers.

There are in this section 28 bridges and viaducts, whose united length is 1297 meters, and 15 tunnels, with 897 meters total length; the culverts are 201, both arched and open. There are 7 stations, among them the very important station of Orizaba, which has the most complete workshops that could possibly be necessary for a railroad.

The third section, from Paso del Macho to Vera Cruz, measures 46 kilometers, with 5 stations, including the terminal stations at the port. In this section there are 10 important bridges, among them the largest bridge on the line, which is that of Soledad, over the river Jamapa. This is a doubly useful bridge, since the wagon-road also passes between its trusses.

The Mexican railroad, besides rendering efficient service in the easy introduction of foreign goods, was the first to benefit the mining industry by opposing the salt monopoly. The mining companies in Pachuca and Real del Monte were obliged to pay as much as $1.60 per arroba of 25 pounds for salt from

the interior. The Vera Cruz railroad, by its competition, reduced this price to 38 cents per arroba.

The branch line, 45.750 kilom. long, which was afterwards built from Ometusco station to Pachuca, has opened a direct communication between that mining town and the City of Mexico and the port of Vera Cruz.

The Mexican railroad connects at Mexico City with all the roads which converge to that point; at Irolo, with the Interoceanic railroad to Vera Cruz and with the Hidalgo railroad; in Apizaco, with the branch to Puebla; at San Marcos, with the Interoceanic again, and with the Nautla railroad; at Esperanza, with the branch to Tehuacan and the line to Xuchil; at Cordoba, with the line to Motzorongo; and at Vera Cruz, with the lines to Alvarado, Xalpa and the Boca del Rio.

III. The Mexican Central Railroad.

This trunk-line, starting at Mexico City, passes through the central part of the Republic, and connects the capital with the cities of Tula (branch-line from here to Pachuca), Queretaro, Celaya, Irapuato (branch-line to Guadalajara), Silao (branch to Guanajuato), Leon, Lagos, Aguascalientes (branch to San Luis Potosí and Tampico), Zacatecas, Torreon (junction with the International and Durango railroad), Jimenez (branch to Parral), Chihuahua (branch to San Andres), and the City of Juarez, the terminal point of the line, on the right bank of the Río Bravo (Rio Grande). The total length of this line is 1970.300 kilom.

The law of September 8, 1880, authorized the construction of lines from Mexico to Leon; from Leon to Paso del Norte; and from some point on said lines (which turned out to be Irapuato) a line to the Pacific, passing through Guadalajara.

In 1880 and 1881 the Mexican Central Railroad Company, Ltd., purchased the concessions from Aguascalientes to San Luis Potosí, and from the latter city to Tantoyuquita and to Tampico.

In 1883 all the concessions owned by the Mexican Central Company were consolidated, which was under the law of September 8, 1880, into a single concession. The law had fixed the dates for commencing the reconnaissance of the lines, and stipulated that the section from Mexico City to Irapuato should be finished at the end of 1881, and as far as Leon in 1882.

For completing the lines from Mexico to the Pacific and to Paso del Norte, five years' and eight years' time, respectively, was allowed, to be counted from the date on which the line from Mexico to Leon might be put into service for the public.

The Government conceded a subvention of $9500, Mexican, for each kilometer of line of 1.44 meter gauge, to be paid in scrip, to be called "Certificates of Railroad Construction," for the redemption of which, without interest, 6 per cent. of the income from the custom-houses was pledged. Moreover, the right of acquiring land by legal proceedings, in condemnation, and also liberal privileges as to free importations and as to exemption from taxes, were granted to the Company, which was also authorized to issue shares, bonds and scrip, and to mortgage its property.

Construction was commenced on May 25, 1880, and carried on with great activity. In September, 1881, the section from Mexico to Tula, 80 kilom., was inaugurated; in December of the same year the line to San Juan del Río, 190 kilom., was opened to traffic; and in February of the following year the line reached Queretaro, 245 kilom. At the end of 1882 it had been opened to traffic successively to Celaya, Irapuato, Leon, the Guanajuato branch, and to Lagos, 475 kilom. from the City of Mexico.

On the Northern division the road was inaugurated to Chihuahua city, 360 kilom. from the City of Juarez, September 16, 1882.

At the end of 1883 the division of Mexico had been finished as far as Zacatecas, 706 kilom., and, besides this, the short branch of 18 kilom. long, between Silao and Marfil. It was operated, however, only as far as Encarnacion, as the important bridge at that point, over the river of the same name, had not yet been completed.

On the Northern division the railroad had, in 1883, a length of 996 kilom., and there were in operation, as far as Lerdo, 829 kilometers.

On March 8, 1884, the last rail of the main line was laid at a point near Fresnillo, belonging to kilometer 765, counted from the City of Mexico; and on the following 10th of April the road was opened to the public from Mexico City to the City of Juarez, with a total length of 1970.300 kilom.

The vast regions traversed by the Mexican Central railroad are important more especially for agriculture; but they also include several mining centers.

The metal and minerals from the Actopan and Cardonal districts come to Tula over the Pachuca branch, 79 kilom. long, which notably favors shipments from Pachuca, Real del Monte and El Chico.

San Juan del Río is the shipping-point for the mining companies at Doctor, Aguas, Maconi, Toliman, San Cristobal Amoles and Río Blanco; for the marble from Vizcarron; and for the opals which abound in Amealco and in Esperanza.

At Celaya the Central railroad connects with the system of the Mexican National railroad, and with the line of Roque and Plancarte (14.600 kilom.).

Kaolin and white clay occur near the station at Salamanca, which is the beginning of the branch to Jaral (35.500 kilom.).

From Irapuato branches off the line to Guadalajara and Ameca (384.500 kilom.); and from the station of Yurecuaro, on this line, begins the branch for Zamora and Cahvinda (61.400 kilom.).

Near Guanajuato the railroad enters a metalliferous region of great fame and present industrial activity. The capital of this State is connected at Silao with the main line by a branch (18.300 kilom.), which reaches to Marfil.

Lagos is the station which receives the minerals from Comanja, Campechana and La Sauceda.

Mining is of very notable importance in the zones which follow along the line. Leaving Lagos, it touches the mercury-bearing region of El Puerto, passing afterward near to the mining towns of Asientos, by a branch from Rincon Romos to the mines of Tepezalá and others in Aguascalientes. From the station at Aguascalientes there is a short line of 3200 meters, to the great smelter of Aguascalientes.

At the Chicalote station is the junction with the line to San Luis Potosí and Tampico, whose total length, taken as beginning at Aguascalientes, is 677.800 kilom.

Zacatecas is a station on the main line, where there is a mineral center of great riches, joined to the mining camp of Ojo Caliente by a short branch of 47.500 kilometers, which brings salt from Peñon Blanco. The mining districts of Fres-

nillo, Sombrerete, San Juan de Guadalupe and Mazapil also are benefited by the operation of the railroad.

Torreon station is the junction with the system of the Mexican International railroad, at which point comes in the branch from Lerdo to San Pedro de la Colonia (63.199 kilom. long), which belongs to the Mexican Central Company.

The extremely rich mining camp of Sierra Mojada is joined to the main line by a branch 125 kilom. long, which connects at Escalon.

At the Jimenez station comes in the essentially mining railroad of Parral, 89.300 kilom. long.

At Chihuahua the Central railroad reaches again a most important mining center, and from that point start the line to the Pacific (now operating 200 kilom., to Miñaca) and the branch mineral railroad to Santa Eulalia.

Finally, at the City of Juarez, which is the terminal point of the Mexican Central railroad, it connects with the Mexican, Rio Grande and Pacific railroad, which touches the mining town of Corralitos.

After the crossing of the Río Bravo (Rio Grande) it also connects, at El Paso, Tex., with the American railway-systems of the Texas Pacific, the Southern Pacific, and the Atchison, Topeka and Santa Fe.

IV. The Mexican National Railroad.

This line competes with the Mexican Central railroad for the traffic between Mexico and the United States. Its location is more advantageous than that of the Central, in that it shortens greatly the distance between the City of Mexico and the Eastern and Southern States of the United States. On the other hand, its construction, especially between the City of Mexico and Toluca, over a very broken country, demanded heavy grades, which make operation costly. The narrow gauge (914 mm., or 36 in.) has also been a great inconvenience, necessitating, for international transportation, a costly transfer at Laredo, Texas, on the frontier of the United States, beyond which the railroads have the standard gauge of 1.44 meters (4 ft. 8.5 in.), which is that of the Mexican Central.*

* Secretary's Note.—The narrow gauge of the Mexican National railroad is the same as that of the original Denver and Rio Grande system, to the con-

The agricultural regions which are traversed by the Mexican National railroad are fertile, since it follows from the valley of Toluca the depression of the important river Lerma, passing afterwards through the valleys of Ixtlahuaca, Acambaro and Salvatierra. The course of the river Laja guides the line through the Bajío, by way of the valleys of Bocas and Jaral, in the States of Guanajuato and San Luis Potosí; and it crosses afterwards the frontier States of Nuevo Leon and Coahuila, to its terminus in Laredo, on the right side of the Río Bravo (Rio Grande).

The concession under which this railway was built was given in 1877 to Messrs. Palmer and Sullivan, representatives of the Mexican National Construction Company, with a stipulation, as in the case of the Mexican Central railroad, for the con-

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struction of which the mining industry of Colorado is so greatly indebted. The practicability of constructing a 36-in. road-bed, where a greater width would be enormously more costly, and of operating such a line with curves and grades not permissible to a wider one, and with light rails and rolling-stock, led to a considerable construction of narrow-gauge railways in the United States 25 or 30 years ago, and encouraged the idea of an extensive system of that kind. Besides the Colorado roads, such lines as that from Toledo to Kansas City, and the Mexican National (the latter of which was projected by the parties who had been so successful in Colorado), may be mentioned as examples. The outcome was a curious and instructive object-lesson. The great chain of connecting narrow-gauge railroads never came to pass, for the simple reason that so many lines, expected to be links in it, developed so much business as to warrant the broadening of their gauges, even at great cost for rock-excavations, the straightening of curves, the enlargement of tunnels, and the purchase of heavier rails and rolling-stock. That the broader gauge universally resulting was that of 4 ft. 8.5 in. is another curious instance of the way in which commercial considerations may overrule technical considerations. This gauge, said to have been originally adopted by reason of the accidental circumstance that it happened to be that of the mine-wagons first hauled by Stephenson's locomotives, is certainly not the best. For certain conditions, a narrower one is superior; and for heavy traffic, a wider one would be, perhaps, safer, and unquestionably be more economical—especially in the consumption of fuel, in the burning of which our locomotives are hopelessly wasteful, because of their necessarily narrow fire-boxes. Great engineers, like Brunel, have proved this point, but in vain. In the United States we have seen long trunk-lines, like the Erie, forced to abandon their broad gauge, not because of its demonstrated defects, but because they could not afford to use what connecting roads did not use. The ability to send cars all over the country, exchanging with other roads, and avoiding delays and transfers of goods, has proved more important than any possible superiority of a special gauge. And so, like the decimal system, and other long-established human institutions, the "standard" gauge has not so much survived because it was theoretically the fittest, as shown itself to be the fittest by surviving!—R. W. R.

struction of a railroad directed towards the Pacific Ocean, in connection with that to Laredo.

The line was subdivided into sections: from Mexico to Toluca, Acambaro and Morelia; from Acambaro to San Luis Potosí; and from Laredo to the interior. On all these sections, work was commenced at the same time, in October, 1880, and was prosecuted continuously until June, 1885, at which time there had been finished: from Laredo to Saltillo, 377 kilom.; Mexico to San Miguel de Allende, 408 kilom.; and the branch from Acambaro towards Patzcuaro, to a length of 154 kilom. In the line to the Pacific, rails were only laid from Manzanillo to Armeria, 45 kilom.

While matters were in this state, financial difficulties caused the transfer of the international part of the line to another company, called the Mexican National R. R. Co. The construction company retained only the division from Manzanillo to Armeria. Under the new company the work was resumed in November, 1887, and on September 28, 1888, was laid down the last rail of the 565 kilom. necessary to unite the Northern and Southern divisions, between Saltillo and San Miguel de Allende. The total length of the line between Mexico and Laredo is 1348.400 kilom.

From the Acambaro station starts the important branch which passes through Morelia, Patzcuaro and Uruapan (total length 230.400 kilom.).

The same company possesses and operates the line from Tacuba to El Salto, 68 kilom., and the line from Matamoros to San Miguel de las Cuevas, 21.58 kilom.

The connections of the Mexican National railroad, not including those in the City of Mexico, are as follows: In Toluca, with the railroads to San Juan de las Huertas, 15.700 kilom., and to Tenango, 27.700 kilom.; at Ixtlahuaca, with a line to Mani, 34.400 kilom.; at Tultenango, with a line to Sandese, 47 kilom.; at Maravatío, with the Michoacan and Pacific railroad, which goes to Zitacuaro, 90 kilom., and with a branch to Angangueo and to Trojes, 5 kilom.; at Celaya, with the Mexican Central railroad; at Dolores Hidalgo, with the Lourdes railroad; at San Luis Potosí, with the Aguascalientes railroad and with the line to Tampico; at Vanegas, with the railroad to Matehuala and Potrero, 65 kilom.; at Saltillo, with the railroad

to Concepcion, 125.460 kilom.; at Monterrey, with the Gulf railroad and with the International railroad; and at Laredo with the Great Northern, of the American system, after crossing the most important bridge of the line, which is that over the Río Bravo (Rio Grande), formed of seven spans of 46 meters each, of Pratt trusses, without counting the approaches, which are more than 200 meters long.

If the agricultural regions traversed by the Mexican National railroad have received great benefit from its opening, the industries in general, and mining, have also received a notable impulse from this artery of communication. The mining towns of El Oro, Tlalpuhajua and Osumatlan have the Tultenango station for the shipping of their ores. Angangueo and Trojes are united to Maravatío by a railroad which starts out from Pozos and Xichú; San Felipe, Maravatío, San Jose de la Chica, Guadalcazar, Charcas, Catorce, Bonanza, Albarradon, Mazapil, Cerro Gordo, Villaldama, Iguana and Candela freight the products of their mines to stations of the Mexican National railroad, whether they are to be treated at the smelters in San Luis Potosí or Monterrey, or exported to the United States.

V. The Mexican International Railroad.

The first contract of the concession for this railroad was approved by the Mexican Congress in November, 1881, and given to the concern which at first was called the International Construction Company, and which promised to construct a railroad without any subvention, although with certain franchises, from the City of Mexico to the Río Bravo, at a point which was afterwards chosen to be Piedras Negras, now called Porfirio Diaz City.

The beginning of the line is in the channel of the Río Bravo (Rio Grande), which forms the boundary between Mexico and the United States, 1500 meters east of the City of Porfirio Diaz.

The road takes a south-west direction, passing by Monclova, and reaching the Reata station, from which starts the important branch which terminates in Monterrey, the capital of the State of Nuevo Leon. From Reata the main line continues in a general westerly direction as far as Torreon, where it makes a junction with the Mexican Central railroad.

The road continues to the south-west as far as Durango, a distance of 869.510 kilom., measured from the City of Porfirio Diaz.

Besides the Monterrey branch, which measures 115.540 kilom., there is a branch from Sabinas to Hondo, 19.310 kilom. long; one from Monclova to Cuatro Cienegas, in the direction towards Sierra Mojada, 68.510 kilom. long; one from Matamoros to Tlahualilo, 70 kilom. long, with a short secondary branch towards Mapimi, 22.530 kilom. long; one from Hornos to San Pedro de la Colonia, 23.900 kilom. long; and the branch from Durango to Papasquiaro, 165.550 kilom. long.

The region traversed by this railroad is largely productive of cereals, which yield a large income of freights; but without a doubt the cotton-bearing zone, fertilized by the river Nazas, the carboniferous zones of Monclova, San Felipe and Hondo, and the mining districts of Muzquiz, Cuatro Cienegas, Monclova, Mapimi, Cuencamé, Durango and Papasquiaro make the Mexican International railroad exceptionally important to the mining industry, especially in Durango. The salt from Viesca also has obtained an easy outlet by this road, cheapening this article, so necessary for the treatment of certain ores.

The Mexican International railroad is the most direct line of standard gauge (1.44 meters) between the capital of this Republic and the States of the American Union; for which reason it enjoys a certain preference on the part of the commerce of exports and imports.

With respect to engineering-works, the only one necessary to mention is the metallic bridge over the river Sabinas, which rests upon two piers and three abutments of mason-work. Of the spans which it has, two are 75.20 meters and one is 38.50 meters long.

The international bridge over the Río Bravo, connecting Porfirio Diaz City with Eagle Pass, is 549 meters long, with five truss-spans of the Howe system.

This railroad began to be operated as far as the Sabinas station, 117 kilom., in December, 1883, and was opened to the public use, division by division, until it united with the Central railroad in Torreon, February 4, 1888, and was inaugurated as far as Durango, October 15, 1892.

The connections of this line are as follows: At Eagle Pass,

with the system of the Southern Pacific; at Reata, with Monterrey, with the system of the Mexican National railroad, and with the railroad from Monterrey to the Gulf of Mexico; at Hornos, with San Pedro de la Colonia; at Matamoros, with Tlahualilo; at Torreon, with the Mexican system; at Pedriceña, with Velardeña; and at Durango, with Santiago Papasquiaro.

VI. The Interoceanic Railroad, from Acapulco to Vera Cruz.

The attraction which this line presents for interoceanic communication through the capital of the Republic caused the Government to extend to it a special protection. The first concession, granted in 1855, as well as several concessions given to other parties afterwards, had no result whatever.

Beginning in 1878, several concessions were granted for the construction of railroads of local interest in the States of Morelos, Puebla and Vera Cruz, which were incorporated in the concession from Mexico to Acapulco and made one consolidated concession for the railroad to Acapulco, Morelos, Mexico, Irolo and Vera Cruz.

The subventions granted by the Government were applied as follows: In cash, $8000 per kilom. for 359 kilom.; $6500 per kilom. for 81 kilom.; $6000 per kilom. for 40 kilom. In certificates of railroad construction, $8000 per kilom. of all the rest of the total length of the line, which certificates were to be redeemed by 3 per cent. of the duties on imports.

Starting from Mexico, the main line towards Acapulco reaches Ameca, 58 kilom.; Cuautla, 138 kilom.; from here to Jojutla, 196 kilom.; Perote, 338 kilom.; Jalapa, 415 kilom.; and, finally, reaches Vera Cruz with a total length of 547 kilom.

There are two short branches—one of 17.300 kilom., between San Lorenzo and San Nicolas, and the other of 10.900 kilom., from Virreyes to Villa Libres.

The railroad is of narrow gauge (914 mm.), with a maximum grade of 2.5 per cent.

There are only two important bridges, which have 50 meters and 70 meters of span, and a tunnel 400 meters long. There is also a wharf at the port of Vera Cruz.

Upon the Southern division there is the bridge of Ozumba, 118.50 meters long, built upon 11 masonry-piers, and 5 more piers built up with rails, properly braced. The trusses are also built up of rails.

The bridge of Nepantla is 31.50 meters long, with unequal spans; some of the trusses are of iron plates, and others of rails. The bridge over the Tinaco gulch is 24.20 meters long, with a span of 14.20 meters in the center, crossed by Warren trusses and beams built up of rails.

The country between Temamatla and Ozumba and Yecapixtla is considerably broken; and the line follows a curved location in order to make the ascent with a maximum grade of 2.5 per cent., and curves which have as little as 100 meters radius.

According to its concession, the Morelos railroad began to be constructed October 17, 1878. The first 25 kilom., as far as Ayotla, were opened to the public August 21, 1878, and the line to Cuautla, 137 kilom., was opened to traffic December 8, 1881, and in the following year the work was continued as far as Yautepec.

On the Irolo line, work was commenced in December, 1880. The line reached Texcoco, 39 kilom., in November, 1881, and Irolo, 90 kilom., in December, 1882.

From the Reyes station, on the main line of the Interoceanic, starts a short branch of 17.700 kilom., to unite that station with the City of Mexico, which was put in operation in May, 1882.

The company acquired the line, 84 kilom. long, from Arcos to Izucar de Matamoros, and from the latter town to Tlancualpican, 40 kilom.

At the present time, it is constructing a line from Chietla, on the latter line, towards Cuautla, which will facilitate the exportation of many products by shortening the distances between certain parts of the State of Morelos and the line to Vera Cruz.

The main line of this company from Vera Cruz to Puente de Ixtla rises first to the central plateau, which commences 171 kilom. from Vera Cruz; then continues on the central plateau 467 kilom. to Nepantla, reaching its highest altitude above sea-level, 2576 meters, at Calpulalpam. From Nepantla follows a descent as far as Puente de Ixtla.

The Interoceanic railroad, in the part constructed and in operation, serves principally the agricultural interests of the

regions which it traverses, and which are so favorable for this industry. In the State of Morelos the production of sugar-cane represents a formidable capital, and engages, by preference, the attention of landowners.

That part of the State of Morelos crossed by this line gives its returns from the transportation of woods and cereals. In the State of Hidalgo, pulque is what produces freights. The States of Tlaxcala and of Puebla also contribute, especially with their agricultural products. The State of Vera Cruz contributes its fruit.

The mining industry is but secondary in the zone which is traversed by this railroad. In the State of Morelos, the districts of Yautepec and Huautla contain mines which are worked on a limited scale. However, the State of Puebla has several mining centers, such as Tlancualpican, Chiautla, Cuyuaca, Tepeyahualco, and other carboniferous centers, such as Acatlan and Izucar de Matamoros.

The connections of this railroad are: at Puente de Ixtla, with the Mexico, Cuernavaca and Pacific railroad; at Tlalmanalco, with the Chalco and Icaczingo railroad, 95 kilom.; at the City of Mexico, with all the roads which center there; at Irolo, with the Hidalgo railroad; at San Lorenzo, with San Nicolas, 17.300 kilom.; at Arcos, with the line to Atlixo, Matamoros and Tlancualpican, 40 kilom.; in Puebla, with the Mexican railroad and with the Oaxaca and Industrial railroad; in Virreyes, with San Juan de los Llanos, 11 kilom.; in San Marcos, with the Mexican railroad and with Nautla; in Jalapa, with the Coatepec railroad.

For import-traffic this line has for its competitor the Mexican Railroad, which, although it has heavy grades to overcome in the ascent, is 123 kilom. shorter in its route. The goods-traffic, and, above all, the passenger-traffic, prefers the most direct lines on account of the shorter time required, and also on account of the standard gauge, which makes the motion more comfortable.

VII. The Monterrey and Gulf Railroad.

This line affords a direct communication between Tampico, the second important port on the Gulf of Mexico, and the northern part of the Mexican Republic. The concession for its construction was granted in November, 1887, and the line

was subsidized with bonds, at the rate of $5000 per kilom.; the bonds being issued at 90 per cent. of their par value, with interest at 6 per cent. a year. By special concession, the line was prolonged in 1889 from Monterrey to Treviño station, on the International railroad, by which means the Monterrey and Gulf became connected with the railroad-system of Central Mexico, and with that of the United States.

Beginning at the general Treviño station, the line is 95 kilom. long to Monterrey; to Victoria City, 390 kilom.; and to Tampico, 625 kilom.

In October, 1888, the work was commenced, and was continued without interruption until the line was opened for operation September 13, 1891.

The line is of standard gauge, 1.44 meters, the maximum grade is 1.5 per cent., and the least radius of curvature is 186 meters. The country followed by the location is easy and not much broken,—which has almost done away with the necessity for costly constructions and heavy earthwork. Of engineering works, there are only the bridges across the great number of water-courses that descend from the Sierra Madre. The longest bridge is that over the Purificacion river, which measures 243 meters.

From Treviño to Monterrey, the descent is along wide cañons of the Sierra Madre, following a line marked out by the structure of the mountains. From Monterrey to San Juan the line follows the north bank of the Silla river to its confluence with the San Juan river and the Ramos river. As soon as the road has crossed these three rivers, it changes its direction, continuing SE. as far as Tampico, traversing the agricultural zone of Victoria City. From Altamira, it runs parallel to the river Tamesi all the way to Tampico.

The agricultural products, the timber and the cattle of that region and foreign imported goods have gained great facilities of transportation to the frontier States over the Monterrey and Gulf line, which have cheapened the cost of freights on such merchandise.

After Treviño, the places of greatest importance reached by this line are Monterrey, Montemorelos, Linares, Ciudad Victoria and Tampico.

Mining, formerly of little importance in this zone, is now becoming a notable factor in the export trade.

The mines of the San Carlos mountains, Croix, San José, Hidalgo, Miquihuana, Bustamante, Palmillas, and some in Nuevo Leon, contribute their part of the traffic on this railroad to supply the smelters at Monterrey.

The Monterrey and Gulf railroad connects with the International railroad at the general Treviño station; with the Mexican National railroad at Monterrey; and with the Mexican Central at Tampico.

VIII. The Sonora Railroad.

The concern which was to construct this railroad was organized under the name of "The Sonora Railroad Company, Limited," and the first reconnaissances were commenced in February, 1880, starting from Guaymas. Construction was commenced in May of the same year, continuing until the completion of the road, which was put in operation in October, 1882.

The concession of the Government allowed a subvention of $700 per kilom. in cash, which was collected upon 422 kilom. of line from Guaymas, the port on the Gulf of California, to Nogales, a town at the dividing-line between Mexico and the United States.

The only places of great importance which exist in the region traversed by this railroad are Guaymas, Hermosillo and Magdalena. The rest of the towns touched by this road are of minor industrial or commercial importance.

Batamotal is the door of the valley of Guaymas, a region very productive of cotton and cereals; and the station is the nearest to the country watered by the Yaqui river.

Mayortena is situated in the center of the cotton district.

Ortiz is the shipping-point for the very rich mines "Dura" and "Suaqui," and for the product of the coal-fields of "La Barranca" and "San Marcial."

Torres station is in railroad-communication with the famous mines "Prietas," "Zubiate," "Trinidad," "Los Bronces," "California," and many others.

Hermosillo is a commercial center of importance as the capital of the State of Sonora.

Pesquiera is the station used by the agricultural and manufacturing interests of the Los Angeles factory.

Carbó station is in the center of a region of great promise in mining. Bacuachito, Santa Elena and San Juan are the most notable mines in the district.

The Santa Ana station is the terminus of the wagon-road which connects the Altar district with the railroad.

The town of Magdalena is also a center of commerce for this line.

Cerro Blanco is connected by a narrow-gauge line of railroad with the mining concern of the same name.

Nogales is the terminal station of the line. Before the railroad was opened in 1882, this was a ranch, with, at most, ten shanties; at present it is a flourishing city, with more than four thousand inhabitants, and with a characteristic commerce, notable for the great harmony existing between the Mexican and American towns, which are almost confounded, being only separated by an imaginary boundary-line.

At Nogales, the Sonora railroad joins the New Mexico and Arizona railroad and the Atchison, Topeka and Santa Fe system of American lines.

This railroad has the standard gauge of 1.44 meters; the heaviest grade is 2 per cent., and the smallest curve-radius is 175 meters.

The bridge over the Sonora river, which is 94.63 meters long, in three spans, is the chief engineering structure; it is of iron, and on a system like the Warren. The other bridges and culverts are of small importance, but considerable in number, having a total length of 10,369 meters.

As appears above, the Sonora railroad serves principally the interests of the richest mining regions of Mexico, in which the development of mining, by its operation, has been the consequence of the great reduction of freights, and other expenses.

IX. The Hidalgo Railroad.

The first concession for this railroad, given in 1878, contemplated the construction of a line which should start from the Teoloyucan station, in connection with the Mexican Central and Mexican railroads, and with another line which was to start from Irolo, where there is a connection with the Mexican and Interoceanic Vera Cruz railroads: the new road to terminate in Pachuca, with a branch to Tulancingo. Both main road and branch were to unite at the San Augustin station, and the latter was to start from the Tepa station. In 1880 the company was authorized to prolong its line to the port of Tuxpan, on the

Gulf of Mexico. The same company was authorized in 1888 to construct also the North-Eastern railroad, which, starting from Mexico, terminated in Tizayuca, a station on the line from Teoloyucan to San Augustin.

In this way there was formed a combination which gives direct communication between the capital of the Republic and the important mining town of Pachuca, and which, when it has reached Tuxpan, will offer the shortest line between the City of Mexico and the Gulf.

Most of the country traversed by these lines is little broken, being a part of the extensive plains in the valley of Mexico between Lakes Texcoco, San Cristobal and Zumpango. Only in the vicinity of the river Papalate, and in the ascent of the watershed between the valleys of Mexico and Tulancingo, and afterwards in the descent to Los Romeros, there is some comparatively rough and broken ground. The maximum grade is 1.80 per cent., compensated in the curves. Of the latter, the sharpest has a radius of 150 meters.

The line of the North-West, including the branch to the custom-house at Santiago Tlaltelolco, is 52 kilom. long, from Mexico to Tizayuca. The several lines which compose the system of the Hidalgo railroad have altogether a length of 162 kilom., divided as follows:

From Tizayuca to Pachuca, 59 kilom.; from Tepa to Tortugas, passing through Tulancingo, 74 kilom.; from San Augustin to Irolo, 30 kilom.

Beyond doubt, the Hidalgo is the road that has contributed most to benefit the mining industry in Pachuca and Real del Monte, by cheapening freight-rates on salt supplies, ores and bullion.

X. The Mexican Southern Railroad.

The Government of the State of Oaxaca obtained in April, 1886, for the construction of a railroad between Tehuacan and the capital of the State, a concession, which was amplified two years after, so that the railroad might be prolonged on one side to Puebla and on the other to Tehuantepec, and was then transferred to an English company, which commenced reconnaissances immediately. Grading was commenced in 1889, and the first division of 127 kilom. was finished from Puebla to Tehuacan in January, 1891, and in August of the same year

97 kilom. further, to Tecomavaca. In 1892 the railroad was completed in its total length, between Puebla and Oaxaca, of 367 kilom.

Starting from the city of Puebla, this railroad runs to Tehuacan over an almost level country, with insignificant grades. The steepest grade is 1.80 per cent., and the sharpest curve has 191 meters radius. The gauge of the line is 914 mm.

Between Tehuacan and Tecomacava the country descends rapidly, with a difference of level of 416 meters in 33 kilom., and the location had to be made zigzag, in order to secure a practicable grade. As far as Tomellin, the line follows the gulches of the Salado, Grande de Quiotepec, Tomellin and San Antonio rivers, with curves of as little as 88 meters radius and short tangents, following which are grades which used to be as great as 4 per cent. to ascend the mountain-range which intervenes, as far as Las Sedas, 44 kilom., before arriving at Oaxaca. The descent to Oaxaca commences abruptly, with a maximum grade of 3.75 per cent., and never less than 1.50 per cent. The curves are continuous.

The formation of the mountains has not permitted an economic location in this section, either for the construction or for the maintenance of way. The line follows the gulches, and, although it is located out of range of the highest floods in the rivers, the currents may undermine the embankments, for which reason constant vigilance and frequent repairs are needed. Moreover, as the line consists more of curves than of tangents, there is extra resistance to traction; and the rolling-stock suffers greatly; and the length and speed of trains must be reduced; all of which makes operation very costly.

As engineering works of importance may be mentioned the bridge over the Salado river, which is 100 meters long, divided into two spans, and two bridges over the Rio Grande of Quiotepec, one 100 meters and the other 80 meters long, in two spans each. The trusses are tubular, of the English pin-and-link type.

In the cañon of the river Salado, or Cues, there are three tunnels, with a total length of 300 meters. Between Tecomavaca and Oaxaca are three other tunnels and a considerable number of bridges, as well as culverts and water-passes. The agricultural region traversed by this railroad is fruitful in the

different products of cold, temperate and tropical climates, and derives the greatest direct benefit from the road. The mining region near Oaxaca is the only one which has profited by it, namely, through the line to Puebla.

The Mexican Southern Railroad connects with the Interoceanic, the line to Izucar de Matamoros, the Industrial and the Mexican railroads at Puebla (50 kilom. long), with the Esperanza at Tehuacan, and with the branch (30 kilom. long) from Las Pilas to Tlacotepec.

XI. The Mexico, Cuernavaca and Pacific Railroad.

By a decree dated May 30, 1890, the first concession was extended to this enterprise, which it was stipulated should be constructed as a line from Mexico to Cuernavaca, the capital of the State of Morelos, and thence to the Barra of Toconoapa, with permission to prolong the line as far as Palizada, on the Pacific coast. In the following year the concession was transferred to the present company, which received some franchises with respect to the metalliferous deposits which might be found during the construction of the line, and to the free importation of a specified list of articles. No subvention was given to the company. In 1895, a change in the contract stipulated that the line should pass through Chilpancingo, the capital of the State of Guerrero, and terminate in Acapulco. At the same time a subsidy was granted, consisting in a payment of thirty Mexican dollars annually for every kilometer in operation during fifteen years, payable in customs-duties. In 1899, another change provided that the line should follow the Balsas river unto a junction with the Inguaran railroad, and finally terminate at the port of Zihuatanejo, on the Pacific coast. Chilpancingo was to be reached by means of a branch-line.

Construction began in 1892, and at the present time 292 kilom. have been completed between Mexico and the Balsas river.

On account of the difficult ground, some engineering works of great importance have had to be constructed, among which may be pointed out the De la Mano gulch; the viaduct between Cuernavaca and Puente de Ixtla; and the bridge, 266 meters long, over the Balsas river.

The most important places upon this line are Cuernavaca

and Puente de Ixtla, where there is a connection with the Interoceanic railroad of Vera Cruz, Iguala and Cocula.

The advantages which the agricultural industry of the State of Morelos derives from this line are very conspicuous, especially for the sugar plantations. The mining industry of the State of Guerrero is also benefited. The mining towns of Taxco, Huitzuco, Tehuilotepec, Limon, Teloloapan, etc., are now enjoying easy and cheap transportation for their products.

XII. The Rio Grande, Sierra Madre and Pacific Railroad.

Two lines are included in this concession: one from Juarez City to Corralitos; and the other from Corralitos to Magdalena, to connect with the Sonora railroad, having a subvention of $8000 per kilom., payable in bonds of the Redeemable Interior Debt. The concession was granted March 24, 1896, and construction was commenced at once from Juarez City. The road is now complete for 250 kilom. It has a temporary bridge over the Río Bravo (Rio Grande), to connect it with the railroads of the United States. Between kilometers No. 182 and No. 183, a branch, 6.575 kilom. long, leaves the main line and runs to the mines of San Pedro.

XIII. The Chihuahua and Pacific Railroad.

Under the name of the Treviño and Pacific railroad a contract was made in May, 1891, for the construction of a series of lines which should connect with the International, the Monterrey and Gulf and the Mexican Central railroads, and terminate on the Pacific coast. This concession was transferred and modified March 31, 1897, and it was stipulated that the road should begin in Chihuahua, to terminate in the State of Sonora. Only 600 kilom. of this road were to be subsidized with $8000 per kilom. in bonds of the Redeemable Interior Debt.

There are now constructed 200 kilom. of this road, between Chihuahua and Miñaca. Cusihuirirchic, Magistral, San Luis Gonzaga are mining towns which already utilize it, as do also, in a certain degree, although at some distance from it, the mining centers of Batopilas, Remedios, Arechuivo, etc.

XIV. Michoacan and Pacific Railroad.

This line begins in Maravatío, on the Mexican National railroad. The main line to Zitacuaro is 100 kilom. long, the maximum grade is 2.5 per cent., and the sharpest curve has 114 meters radius; the gauge of the line is 914 mm.

Upon the branch which starts from kilom. 46 towards Angangueo, with a length of 736 meters, and on the branch which starts from kilom. 49 towards the Trojes smelter, and is only 1076 meters long, the curves are as low as 95 meters radius, and the grades as high as 4 per cent.

This railroad is of great importance for mining, since it follows the valley between the mountain-ranges of the mining regions of Angangueo and Tlalpujahua, and has, as its center of operations, the Trojes metallurgical works.

XV. The Mexican Northern Railroad.

This line, called at first the Mining railroad, received a concession, without subvention, March 20, 1890. The whole system has a length of 130 kilom., of which the main line is that which begins at Escalon, on the Mexican Central railroad, and terminates in the mining town of Sierra Mojada, with a length of 125 kilom.; the rest of the system is composed of short branches, for the service of mining concerns. This line, which is of interest to mining only, has largely contributed to the development of that industry. In the fiscal year 1898–99, the freights over it amounted to 363,785,441 tons, chiefly ores, coal and wood.

XVI. Railroads in Yucatan.

The network of railroads in the State of Yucatan and a small part of the State of Campeche is of great importance from a commercial point of view, and with especial relation to the hennequin industry. The high price which the hennequin fiber has reached in the markets of the United States and Europe has induced the extension of plantations on a large scale to places where the construction of railroads was necessary to prompt communication with the ports of exportation.

Merida, the capital of the State of Yucatan, is the center to which converge all the constructed lines, the names and lengths of which are as follows:

	Kilom.	Meters.
Merida to Progreso,	36	456
Merida to Izamal,	66	848
Merida to Izucakab (line to Peto),	138	......
Merida to Tunkas (line to Valladolid),	118	......
Branch from Conkal to Progreso,	30	688
Merida to Campeche,	172	119
Branch from Uman to Hunucmá,	20	375
Branch to Lerma,	6	......

At the present time this system is being extended in the eastern part of Yucatan. Apart from its effect in stimulating the plantations, it will constitute a network of strategic lines for the protection of public tranquillity.

XVII. Railroads in the Federal District.

The street-railroad lines in the City of Mexico are worth mentioning. They have a total length of 97.570 kilom.

In the reconstruction of the lines to Tacubaya, San Angel, Mixcoac, Tlalpam, Coyoacan, Tlaxpana and Colonia de Arquitectos, Peralvillo and Belem, Peralvillo and La Viga, Central Circuit and Guadalupe Hidalgo, animal has been replaced by electric traction.

The reconstruction of the rest of the lines continues with activity, so as to adapt them to the electric system, which, without doubt, will be used all over the city before the end of 1902.

XVIII. General Conclusions.

The recent great extension of the railroad-system has increased to a remarkable degree the importance of Mexican mining. Distant regions, almost inaccessible before, have been opened to the visits of engineers, promoters and working miners, and the great mineral production of Chihuahua, Durango and Coahuila, etc., bears witness to the result.

The railroads have not only reduced freight-charges on ores and supplies, but also permitted the introduction of modern machinery, the weight and bulk of which would have prevented its transportation by any other means. This has led to the adoption of new mining and metallurgical methods, together with the new apparatus.

The exportation of the richer ores, for perfect treatment, has been made possible by the same agency. A few years ago no

one imagined that the low-grade products of the mining centers of Guerrero, Hidalgo, Michoacan, Guanajuato and other States, and even the really poor ores and the very dump-piles, could be worked, so as to yield, with profit, almost the total amount of the precious metals which they contain. Yet this is now done, after paying the cost of transportation to Aguascalientes, San Luis Potosí, Monterrey or Chihuahua,—important metallurgical works, the creation of which we owe to the facilities of transportation furnished by the railroads.

Such mining concerns as were in the country were seriously distressed by the scarcity of fuel, which was more and more notable as time advanced. Mining companies, like some at Pachuca and Real del Monte, went so far as to buy timber lands partially deforested, to replant them, and submit them to a rational exploitation, under the premonition of an industrial crisis for want of wood. The railroads came in time to save them from this dangerous situation, allowing the importation of coal from foreign countries, and the working and transportation of the coal of the northern frontier States of Mexico.

The railroads have not only thus aided the gold- and silver-mines, but have also helped to make possible and profitable the working of coal-mines in Coahuila, iron-mines in Durango and Jalisco, lead-mines in Sierra Mojada, and copper-mines in Aguascalientes and Michoacan.

Some specific data will give an idea of the benefits which have been wrought in favor of mining by the creation of the railroad-system.

The use of coal was formerly impracticable; to-day coal is obtained at from $18 to $25 per ton, after deducting the waste.

Salt cost 32 years ago $0.98 per arroba, and its present price is $0.38 per arroba; the saving is 61.22 per cent. Imported iron is obtained now at 50 per cent. of the price at which it was quoted 32 years ago.

The cost of treatment, apart from the quicksilver, of a ton of ore in barrels, 32 years ago, was $12.51; in 1900 the cost was only $10.23, an economy of 16.21 per cent.

The cost of treatment by the *patio* process, without including quicksilver, in the Loreto hacienda, 32 years ago, was $16.57; in 1900 the cost was $11.59, a saving of 30.95 per cent.

The freight-charge from Pachuca to Mexico City, by wagons,

was $20 per ton. At present, the second-class freight-rate is $5.50 per ton on the railroad.

The freight-rate from Vera Cruz to Pachuca on wagons was very variable, but the average rate per ton may be estimated at $120; at present the rate is less than $30 per ton by rail, and for coal only $12.

The mineral product in the Mexican Republic (*a*) before the building of the railroads; (*b*) at the completion of the Mexican Central railroad; and (*c*) at the end of the last fiscal year, was as follows:

Years.	Gold.	Silver.
a. 1872–1873, ...	$976,000	$21,441,000
b. 1882–1883, ...	956,000	29,569,000
c. 1900–1901, ...	8,848,005	72,368,795

To the production during the fiscal year just ended should be added the value of the lead and copper, estimated at $15,-134,181.

Mexico, at the present time, is not a country whose agriculture and manufactures leave a surplus that can be sent to foreign countries in exchange for their products. It is principally the mining industry which pays for our outside purchases, either with the products of the mines in the shape of ores, or with silver bullion from the same source.

The future expansion of the railroad system of Mexico is thus indicated to be in a direction towards the regions of mining production, and towards the ports of exportation. A single glance at the mining- and railroad-map which accompanies this hasty synopsis will enable any one to comprehend the lines of penetration which are under construction to be connected with the lines already established: especially the Rio Grande, Sierra Madre and Pacific; the Chihuahua and Pacific; Michoacan and Pacific; Mexico, Cuernavaca and Pacific; the prolongation line from Jimenez to Parral; the continuation line from Guadalajara to Manzanillo; the line from Durango to Mazatlan, etc.,—all of which are so favorable to mining that they will not only enable this industry to pay for importations, but also will leave a surplus in the country to stimulate other industries, and to be invested in internal improvements, which will convert the Mexican Republic into a rich and flourishing country.

Notes on the Potable Waters of Mexico.

BY ELLEN H. RICHARDS, MASS. INST. OF TECHNOLOGY, BOSTON, MASS.

(Mexican Meeting, November, 1901.)

THE water-supply of a country may be considered from three points of view: (1) its abundance and availability for agricultural purposes; (2) its chemical properties in their relation to manufacturing purposes; and (3) its quality and quantity as affecting domestic consumption.

This paper concerns only those characteristics which may affect manufacturing and domestic uses. The so-called sanitary analyses deal not only with the common mineral elements found in water, but with organic matter and with those substances which, by their presence, indicate changes taking place through the agency of living organisms. Since these living organisms are frequently accompanied by others, capable, as we believe, of causing disease, the products of their action are looked upon with suspicion even when, as in the case of nitrates, that action may have taken place at a time long past. Therefore, upon the quality of the water-supply depends much of the history of a country, when rightly read, as well as much of its promise for the future.

Thus, the "hardness," or content of calcium and magnesium salts, gives a means of distinguishing at once between the waters traversing only igneous or other siliceous rocks and those coming from calcareous deposits. The presence of decomposing organic matter and intermediate products betrays a use of the water as the public carrier of refuse, which renders doubtful its fitness for domestic supply.

In certain regions, one of the most valuable historical records is made by the relative amount of chlorine in the different waters. In the absence of rock-deposits carrying salt, the chlorine present in rain and snow, and hence in mountain-streams and springs, appears to be derived from the air-borne, finely divided salt spray resulting from the beating of the ocean waves on the coast. If this be true, then the amount of chlorine found in a given water not contaminated with chlorides

from other sources will vary with the distance from the shore, the character of the shore, and the presence or absence of mountain ranges which intercept and precipitate the moisture.

The lessons taught by the study, in recent years, of the height to which fine dust rises in the atmosphere, and by the seemingly well-substantiated fact that these dust-particles condense around themselves a film of moisture, seem to warrant the attempt to construct, for similarly situated regions of land, lines of equal chlorine ("isochlors"), which indicate the "allowable" chlorine for each locality. For an accurate determination, a series of tests covering a considerable time is needed; but if the volume of water is considerable, a fairly close approximation may be made by a number of single tests. Thus, the isochlors for Jamaica were plotted from the results of 70 samples, collected in one journey covering the length and breadth of the island.* Waters, both superficial and percolating, possess a great solvent and transporting power, so that the residual contents at any place give some indication of the distance and the rock-formations traversed since the fall of the rain or snow, and also give some evidence as to the previous use, and the cleanness or foulness, of the soil through which the waters have filtered.

These isochloric lines give a basis from which to argue that if, in a given case, chlorine is present in excess of the "normal," it must have entered the water by human agency, thus indicating a previous use of the water by man, and hence a possible pollution. Chlorides are especially adapted to this historical tracing of use, because, as a general rule, after they have once entered the water, they are not removed either by rocks or soil, forming therewith insoluble combinations, or by plants, as a means of growth. The first of these changes occurs in the case of phosphates; the last, to a certain degree, in the case of nitrates.

The determination of the "normal chlorine" of a country has, therefore, great sanitary value. Advantage was taken of the excursion of the American Institute of Mining Engineers to the Republic and City of Mexico to obtain samples of water, the analysis of which should at least indicate the probable

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amount of this telltale element, and furnish both a basis and an impulse for more extensive investigations.

The inland waters of the United States, when quite unpolluted, show one part (or less) of chlorine per million. Roughly speaking, this point is reached at about 100 miles from the coast, and remains fairly constant for the interior. The mountain-lakes of the Adirondacks show less than half that amount, while bodies of water within 50 miles of the sea contain about 2.5 parts, and those within ten miles of the sea about 10 parts, per million. Every time water is discharged into a stream or underground reservoir, after use by man, it carries an excess of chlorine. Ordinary city-sewage contains from 25 to 60 parts, and house-sewage two or three times as much.

From the table of analyses given herewith, it will be seen that the Cordilleran Plateau of Mexico furnishes water containing approximately the same proportion of chlorine as other inland regions of North America, and that isochlors may be drawn after more determinations have been made. The results at hand will surely be of advantage in the future sanitary surveys, which a government so wide-awake as that of Mexico will be sure to execute.

The sample from Ajusco, on the divide, showing chlorine 0.9 part per million; that from Cuernavaca, on the Pacific side; and that from Pachuca, on the east,—each showing about 1.0 part and each about 100 miles from the coast,—may be taken as typical. The five others, placed in the first class, approach this limit, and are distributed over the plateau from north to south at distances of about 200 miles from the sea. The anciently famous spring at Thalpan undoubtedly belongs here. Unfortunately, the sample was lost by breakage of the bottle, after the preliminary test.

Classes II*a*, II*b* and III. show from two to three times the chlorine of those waters which we may for the present assume as normal.

Class II*a* includes those which show no nitrogen. In Class II*b* is the sample taken from the reservoir at the new dam at San Luis Potosí. This water is placed here because the analysis indicates the probability that, when the collecting ground is washed clean and protected (as it is to be), this water will belong here—if, indeed, the chlorine is not quite normal.

Sanitary Analyses of Mexican Waters.

(Parts in 1,000,000.)

No.	Locality.	Physical.			Residue on Evaporation.			Nitrogen as				Hardness.	Chlorine.	Iron.	Carbon Dioxide.	Sulphates.	Silica.	Calcium Oxide.	Magnesium Oxide.
		Color.	Turbidity.	Sediment.	Total.	Loss on Ignition.	Fixed.	Alb. Am'nia. Total.	Free Am'onia.	Nitrites.	Nitrates								
	Class I.																		
1...	Ajusco, on the Divide, from hydrant at the station.	0.10	none	decided earthy	98.5	12.5	86.0	0.072	Nov. Dec. .200 .048	Nov. Dec. .001 .010	0.000	16.3	0.89	0.100	....	v. slight	......	.. ..	......
2...	Hydrant, Pachuca.	0.13	"	sl. floc.	84.5	6.5	78.0	.. ..	slight	0.000	0 000	21.5	1.05	0.100	faintly acid	v. slight	...	.. ..	....
3...	Fountain, Cuernavaca, Hotel Morellos.	0.00	"	v. sl.	119.0	9.0	110.0	... ..	0.060	0.000	0.000	28.6	1.09	0.010	....	slight	. ....	......	......
4...	Spring, Santa Barbara, on hill near Montezuma mill.	0.00	"	sl. earthy	364.0	......	....	......	v. sl.	0 000	0.000	215.0	1.17	0.080	faintly alkaline	distinct	......	......	.. .. .
5...	Drinking tap, Real del Monte.	0.35	"	sl. floc.	87.0	5.0	82.0	......	Nov. Dec. .400 .360	Nov. Dec. .000 .0005	0.000	11.1	1.21	0.035	faintly alkaline	....	......	......	... ..
6...	Marfil, below Guanajuato, from hydrant at station.	0.10	slight settling out	slight earthy and rusty	209.0	......	. .....	......	0.060	0.000	0.000	116.5	1.49	0.140	....	slight	......	......	......
7...	Monterrey, spring at the Diente.	0.07	none	consid. earthy	250.0	.....	....	... .	0.000	Nov. Dec. .000 .001	0.200	185.8	1.65	0.200	acid	slight	.. .	... .	......
	Class IIa.																		
8...	Chihuahua, town-supply, tap.	0.00	"	slight earthy	306.0	... .	... .	.... .	none	0.000	trace	134	2.96	0.050	faintly acid	distinct SO_3 272.	.. .	. . .	... ..
9...	River in Choy Cove.	......	"	none	828.0	.....	. .. . .	. ....	... .	0.000	0.000	471.5	3.34	0.200	....		36.0	253	....
	Class IIb.																		
10...	Dam for new supply, San Luis Potosi, not ready for use.	. ....	distinct settling out to nearly clear.	consid. earthy yellow	115.0	22.5	92.5	0.340	1.220	0.003	0.000	22.1	2.48	0.700	....	....	......	.... .	6.0

11...	"Drink water," San Luis Potosi.	......	milky, not settling	sl. earthy	206	22.5	183.5	0.088	0.152	Nov. Dec. .000 .001	0.600	11.1	3.69	0.950	....	v. slight	......	......	..
	CLASS III.																		
12 ..	Driven well, Guadalajara, Calle Merced.	0.20	v. f. milky	slight earthy and rusty	210.5	23.0	187.5	......	Nov. Dec. .200 present	Nov. Dec 001 .004	5.000	6.3	1.89	5.250	2.64	slight	......	......	.....
13...	Hydrant, Guadalajara, Calle San Francisco.	0.20	dist. milky	sl. earthy	237.5	.. ..	....	0.060	Nov. Dec. .200 .000	0.000	4.500	14.3	2 74	0.110	0.44	.. . .	......	......	.....
14..	Filter well, Guadalajara, said to be best in Republic.	0.07	none	v. sl.	215	......	....	......	faint	0.000	6.000	34.5	3.81	0.100	3.52	slight	......	.. ..	... ..
	CLASS IV.																		
15...	San L. Potosi well, 500 ft.	0.10	"	sl. floc.	205	27	178	0.060	0.232	Nov. Dec. .000 002	0.000	14 3	6.00	0.040	. ...	....	......	......	......
16...	Guanajuato.	0.15	"	sl. rusty	384	. ...	. . .	0.072	0.000	0.000	0.000	200.0	7 01	0.160	....	decided	...	......	......
17...	Hydrant, San Luis Potosi, in Plaza.	0.15	dist. white milky	v. sl.	300	......	....	0.048	0.000	0.000	0.600	15.6	13.47	0.100	....	distinct	.....	. . .	.. ..
18...	Pool at Bridge of the Gods, Cafetal (?) or Cardenas. Tropical vegetation.	......	none	none	780	....	....	......	0.200	0.001	0.150	414.5	14.30	0.080	.. ..	... . .	.....	.. .	.
19...	Hot springs, tap west side of station, Aguascalientes.	0.00	"	v. sl.	554	......	....	0.000	0.000	0.000	0.100	342.8	16.09	0.040	....	decided	40.0	91.0	......
20...	Marzio 18. Artesian well on drainage canal.	0.00	"	none	475	......	....	......	Nov. Dec. .060 .000	0.000	0.100	107.5	26.41	0.020	Reaction alkaline	slight	58.5	31.0	27.0
	CLASS V.																		
21 ..	From vendor, Aguascalientes. Spring in mountains.	0.10	milky, settling clear	dist. earthy	298	......	. .... .	......	Nov. Dec. dist. none	Nov. Dec. .010 .100	4.250	76.4	6 41	0 050	....	slight	... .	.....	......
22...	Aguascalientes, tap from river. Smelting-works.	0.30	distinct not clear'ng	decided earthy	405	......	....	0.200	0 000	Nov. Dec. .001 .000	0.000	122.6	8.90	0.100	....	slight	......	... .	.. .
23 ..	Baroteran, tap at Mine Office.	0.02	milky, settled out	consid. rusty	556	......	....	0.120	0.080	Nov. Dec. .005 .0005	1.000	287.4	14.30	0.400	acid	decided	. .	......	..
24...	Aguascalientes, tap in Plaza.	0.00	none	v. sl.	457	......	....	0 000	Nov. Dec. pres't .000	Nov. Dec. .001 .000	0.350	165.8	17.53	0.020	....	slight	......	......	......
25...	Spring, Chihuahua, used for drinking.	0.00	"	v. sl. earthy	444	.... .	....	......	0.000	.000	1.500	221	18.87	0.100	1.76	distinct slight	55.0	115.	......
26...	Drinking fountain, Zacatecas.	0.10	"	sl. earthy	480	.....	. ...	0.108	0.000	Nov. Dec. .000 .040	3.500	314.5	32.77	0.000	alkaline	distinct slight	.. .	.....	... ..

Sanitary Analyses of Mexican Waters—Continued.

(Parts in 1,000,000.)

No.	Locality.	Physical.			Residue on Evaporation			Nitrogen as				Hardness.	Chlorine.	Iron.	Carbon Dioxide.	Sulphates.	Silica.	Calcium Oxide.	Magnesium Oxide.
		Color.	Turbidity.	Sediment.	Total.	Loss on Ignition.	Fixed.	Alb. Am'nia. Total.	Free Am'nia.	Nitrites.	Nitrates.								
	Class VI.																		
27...	Pachuca, reservoir below pic-nic-ground.	0.15	decided settling clear	consid. rusty and floc.	162	......	....	......	Nov. Dec .400 1.200	Nov. Dec .008 .060	1.000	58.6	5.45	0.020	faintly acid	....	.	......	......
28...	Monterrey, well in hotel.	......	none	v. sl. floc.	458	......	....	... ..	Nov. Dec. .200 .200	Nov. Dec. .002 .005	4.500	251.2	6.99	0.010	reaction acid	distinct	76.5	127	......
29...	Hotel Guadalajara, said to be filtered rain-water.	0.10	"	v. sl.	441	......	....	0.080	Nov. Dec. 1.200 .268	Nov. Dec .020 .200	9.500	65.7	16.54	0.050	0.88	slight		. ....	......
30...	Parral, badly polluted stream, from carafe on table.	0.00	slightly turbid, later clear	sl. earthy	566	. .	.. ..	0.080	0.000	Nov. Dec. .040 .010	15.000	224	89.77	0.040	faintly acid	distinct	. ..	.. .	......
	Class VII.																		
31...	Mineral waters. Holy well, Guadalupe.	0.20	....	....	1820	......	....	0.260	1.080	Nov. Dec. .001 .005	0.000	545.0	218.4	25.2	44.0	decided	.... .	......	223.
32...	Mineral water below San Luis Potosí.	1.20	milky	consid. rusty	700	......	....	......	0.400	0.000	0.000	371.5	167.2	0.120	....	distinct	18.0	189	......

Sanitary Analyses of Mexican Waters—Continued.

No.	UNCLASSIFIED.	Date of Collection. 1902.	Date of Examination. 1902.	Total Residue.	Chlorine.	Nitrogen as Nitrites.	Nitrogen as Nitrates.	Hardness.	Iron.
33	Water from spring at Ubero plantation, Isthmus of Tehuantepec.*	Feb. 27	Mar.	70.5	4.78	.002	1.800	30.6	0.330
34	Water from Junnupa River.*	"	"	103.0	5.46	.000	.000	41.0	0.550

The other sample contains some nitrate, which, however, is not sufficient to render it suspicious; and the ammonia is accompanied by iron—a not uncommon occurrence in deep-seated waters, especially those which have been in contact with the sandstones above the Coal Measures. The presence of chlorine without nitrates may mean one of two things: either (1) that the source of the chlorine is in old rock-formations, still bearing traces of marine deposition; or (2) that the nitrates once present have been completely removed by vegetation, or that, in various transformations underground, they have disappeared, and with them any dangerous accompaniments.

Class III., containing the three samples from Guadalajara, gives evidence of the slow percolation of surface-drainage to the underground sources, since not only is the chlorine increased, but nitrates are present in high amounts.

Class IV., with high chlorine and low nitrogen in any form, should offer interesting lines of study for the geologist.

Class V., with nitrates present, stands intermediate between IV. and VI., which latter class may be said to comprise waters which show undoubted pollution, having all the marks of previous use which are held in other countries to be conclusive on this point.

Class VII. contains two samples of highly-charged mineral water, in which both the chlorine and ammonia may have been derived from geological formations, rather than through contamination from human sources.

Further examination of the well of Guadalupe is needed to determine the geological horizon from which the water is de-

* Collected by Prof. F. L. Bardwell, of the Mass. Institute of Technology.

rived. In the case of the other well, the remarkable variation of temperature indicates that it may be a mixed water. Further tests at different seasons are needed.

The only soft waters are from the vicinity of Mexico City, Ajusco, Thalpan, Cuernavaca, and Pachuca, and two at San Luis Potosí.

As to the mineral contents, it is not surprising to find considerable silica and much calcium carbonate in the waters coming in contact with the warm *tepetate* or *caliche*.

The comparatively rare occurrence of magnesium and of sulphates is favorable to the quality of the water for domestic and manufacturing purposes, since it is comparatively easy to remove the calcium carbonate.

The water which escapes from the plateau and passes underground to the sea may be considered to be represented by the sample from the river in Choy Cove, and the artesian well on the drainage-canal near Zumpango.

Mexico may act in time to save her good water-supplies, if she will take to heart the lesson, so dearly bought in the United States, that it is cheaper, as well as wiser, to protect from pollution than to purify afterwards.

Additional Notes.

The tap in the railroad-station at Juarez gave a hardness of 300, and showed high chlorine and sulphates, with considerable carbon dioxide. Ammonia, nitrites and nitrates were very low or absent. This and other evidence indicate a deficiency of nitrogen in the arid region.

It was most unfortunate that the bottle containing the sample from the famous spring at Thalpan was broken before the final tests were made. The water is said to come out from under the volcanic sheet forming the last eruptive rock in the valley. The water is barely acid with carbon dioxide; shows normal chlorine with no nitrogen in any form; and a hardness of only 13 per million, thus sustaining the high reputation it has had for so many decades.

Some of the supplies of the City of Mexico are nearly as good as this; others are much harder and less free from contamination.

That water derived from the hard soil is at times polluted,

as is that from gravelly formations, is shown by a sample from Zumpango, which gave a hardness of 63, and ammonia, 1200; nitrites, 30; nitrates, 20; with high chlorine and some sulphates.

As was to be expected, few samples gave any considerable amount of the salts of potassium and sodium. In a few cases determinations were made, and the results will be found in the table.

In consequence of the small amounts of nitrates usually present, there was, at the season in which these observations were made, very little of that growth of green plant-life which is so characteristic of many of the northern water-courses.

The objectionable blue-green alga *Anabœna* was observed only once, at the Borda garden, Cuernavaca, where the air was heavy with its unmistakable odor.

A microscopical examination, made some two months after the samples were collected, showed a very wide distribution of diatoms, both of common and of unusual forms.

Varieties of *tabellaria*, *fragilaria*, *navicula* and *synedra* were common. Very few green *algœ* were developed. Now and then a form of *palmella* was observed.

In several samples the diatoms had a sheath or envelope of oxide of manganese, after the manner of iron oxide about *crenothrix*.

In conclusion, it may be stated that this examination, imperfect as it is, was made possible by the use of a portable case of apparatus* and reagents, carefully standardized just before leaving the laboratory at Boston. By this means certain tests were made on the spot, both to determine what samples it was worth while to bring north, and to make the transportation of a smaller sample compatible with good work. Moreover, a comparison of the results reached on the spot with those of a month later permits an opinion to be formed as to the changeable character of the organic matter.

My thanks are due to Miss I. F. Hyams for aid in making the preliminary tests during the journey, and to many members of the Institute party for aid in collecting the samples.

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* Figured and described in the *Technology Quarterly*, vol. xiv., page 295.

The Steel-Plant at Monterrey, Mexico.

BY WILLIAM WHITE, JR., PITTSBURG, PA.

(Mexican Meeting, November, 1901.)

History.—The making of iron and steel from the ores of northern Mexico was for years a favorite project of the late Don Patricio Milmo, upon whose estate large deposits of coal and iron were known to exist, and with whom Mr. Eugene Kelly, of New York, was associated.

Several expert examinations of the property were made for them; and when failing health forced Sr. Milmo to retire from active part in the matter, Mr. Kelly carried on the project and associated himself with Messrs. Vicente Ferrara, of Monterrey, Antonio Basagoiti and Leon Signoret, of the City of Mexico, and other leading citizens of Mexico, Monterrey and New York, who, in May, 1900, organized the "Compania Fundidora de Fierro y Acero de Monterrey," with a capital of $10,000,000.

The main reason for locating the plant at Monterrey was, that a circle drawn with Monterrey as a center, and the distance from Monterrey to Laredo as a radius, will contain all the known deposits of iron-ore of Bessemer quality, and the greater part of the available coal, in the Republic. Moreover, Monterrey is connected with all the Mexican trunk railway-lines, and thus with the Gulf of Mexico, and supplies, therefore, the conditions necessary for prosperous manufacturing, namely, cheapness in assembling raw materials and means for wide distribution of product. It also has a number of enterprising citizens, who have been successful in mining, smelting and manufacturing operations, and a sufficiently large population to supply the necessary labor.

Iron-Ore.—The company's iron-mines are on the Carrizal mountain, on the Mexican National, and at Monclova, on the Mexican International railroad. At the former locality, two mines, *Piedra Iman* and the *Anillo de Hierro*, sufficiently large

to supply all present needs, are now under development. They are, reached by a 5-mile branch from Golondrina station, on the Mexican National. The ore is brought to the loading-terminal by two Bleichert tramways, arranged to load 1000 tons per day.

The outcrop of the *Piedra Iman* is a ridge 79 ft. wide and 300 ft. high; that of the *Anillo de Hierro* is 120 ft. wide. Developments indicate the persistence of the deposits in depth. A third very large deposit is the *Cinco de Mayo*, which will be developed as occasion requires. The ore of the *Piedra Iman* is magnetite; that of the *Anillo de Hierro*, hematite; and that of the *Cinco de Mayo*, brown hematite.

The analyses of the ores by Dr. Otto Wuth, of Pittsburg, are as follows:

Analyses of Mexican Iron-Ores.

	"Piedra Iman." Magnetite.	"Anillo de Hierro." Hematite.	"Cinco de Mayo." Brown Hematite.	"Monclova."	
				No. 1.	No. 2.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Silicic acid	5.41	2.42	2.90	2.51	3.85
Alumina	1.03	.79	1.12	1.51	1.04
Peroxide of iron	....	96.22	78.86	95.05	93.42
Magnetic iron	90.83	....	....	....	....
Lime	1.93	.10	4.25	.28	.85
Magnesia	.42	trace	1.60	.12	.05
Peroxide of manganese	.25	.37	4.51	.43	.27
Sulphuric acid	trace	none	trace	trace	.47
Phosphoric acid	.130	.101	.051	.101	.050
Copper	none	none	trace	....	....
Metallic iron	65.76	67.35	55.20	66.53	63.39
Phosphorus	.056	.044	.022	.044	.022

Coal.—The company owns 30,000 acres of the Laredo coal-field, and is largely interested in that of Barroteran. Developments made in the latter field by the Mexican Coal and Coke Co. show a coal-seam 9 ft. thick, and of a quality suitable to the manufacture of coke for blast-furnaces.

The analysis of this coal and coke is as follows:

Analysis of Barroteran Coal and Coke.

	Coal. Per cent.	Coke. Per cent.
Moisture,	2.00	......
Volatile matter,	20.50	1.40
Fixed carbon,	67.70	87.30
Ash,	9.80	11.30

Limestone.—Monterrey is in a district which furnishes limestone of exceptional quality and in inexhaustible quantity.

Manganese.—Ores varying from 40 to 55 per cent. of metallic manganese, and low in phosphorus, are available, so that the manganese required for the steel-manufacture need not be imported.

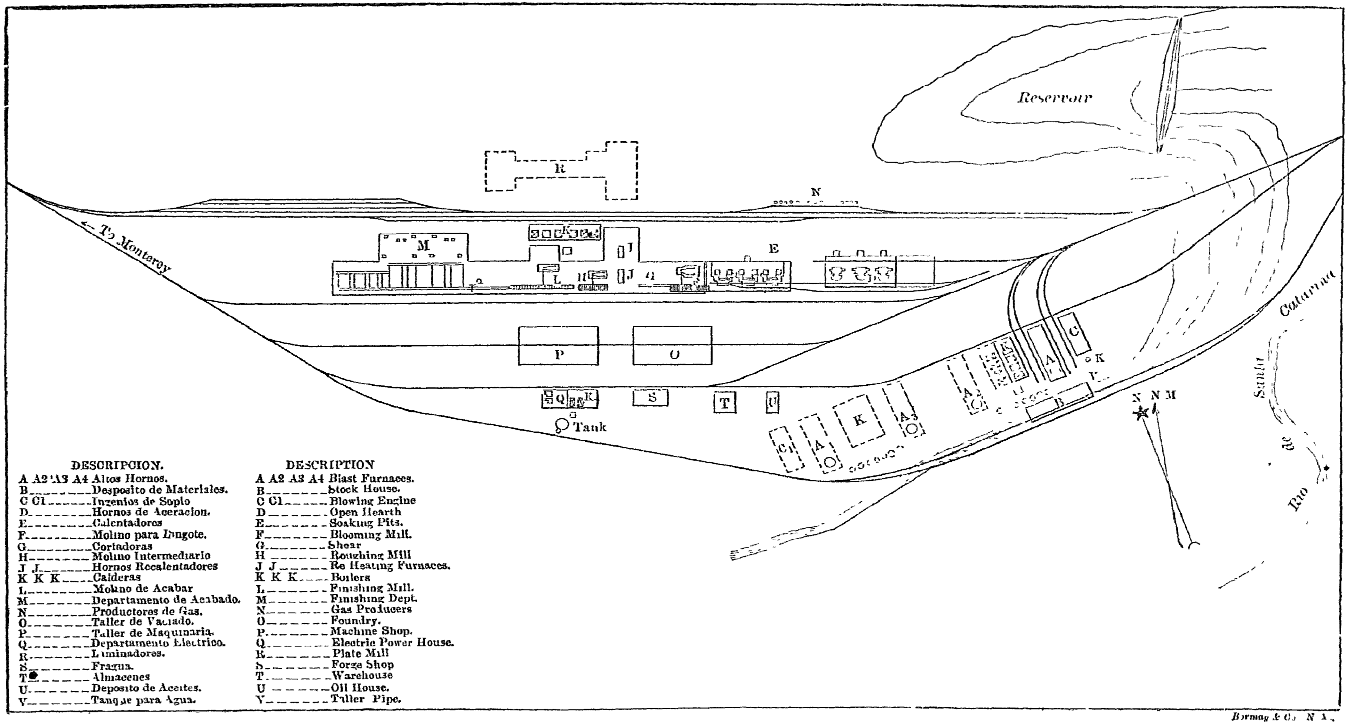
The Plant.—The plant of the company, a plan of which is shown in Fig. 1, is located on a tract of about 600 acres, 3 miles east of Monterrey. The buildings, of steel-frame construction, fabricated by the American Bridge Co., have the following dimensions:

	Feet.
Blast-furnace stock-house,	200 x 50
" " cast-house,	180 x 50
" " blowing-engine house,	130 x 50
" " boiler-house,	135 x 50
Open-hearth building,	204 x 100
Mill-building,	1284 x 100
Mill boiler-building,	200 x 50
Rail-finishing building,	196 x 50
Foundry,	225 x 220
Machine-shop,	225 x 120
Power-plant,	156 x 56
Forge,	100 x 50
Store-house,	60 x 60
Oil-house,	60 x 30
Laboratory,	35 x 45

A number of brick houses and offices have been and will be built, in order to keep the employers in close connection with the work; and, with the same object, a large number of tenements will be erected for the workmen.

The output of each department can be increased or diminished as conditions warrant; and the capacity per annum may be stated in tons as follows: rails, 40,000; beams and shapes,

FIG. 1.



Plant of the Monterrey Iron and Steel Company.

40,000; billets and bars, 10,000; pig-iron, 30,000; castings, 8000; total, 128,000 tons.

The mills are planned for a much larger output than this, and could, in fact, take care of the product of four blast-furnaces.

Blast-Furnace.—The furnace, built by the W. B. Pollock Co. of Youngstown, Ohio, is 80 ft. high by 18 ft. bosh-diameter, is equipped with four Massick and Crook hot-blast stoves, 19 ft. 6 in. by 75 ft. in size, and six Babcock and Wilcox boilers in batteries of 680 H.P. each. There are two pairs of vertical, compound, condensing, blowing-engines, built by the Wm. Tod Company of Youngstown, Ohio, with blowing-cylinders 84-in. by 60-in. stroke, and steam-cylinders 42 in. and 80 in. in diam. respectively. Arrangements are made to carry the molten metal direct to the open-hearth furnace. The estimated product is 350 tons of pig-iron per day.

Open-Hearth Furnaces.—There are three 35-ton furnaces, and room is provided for two more, of 50 tons capacity. They are served by a 50-ton electric traveling-crane, built by the Morgan Engine Company of Alliance, Ohio, and an electric charging-machine which charges scrap and cold pig. Molten pig can be charged direct from the blast-furnace. It is intended to cast the product of the open-hearth furnace into moulds standing upright on cars. The reason for making exclusively open-hearth steel was that the wide range and variety of the Mexican market demand could be best met by that product; but room was provided on the plans for the addition of a Bessemer plant, adequate to a large output of rails, whenever such a course might become desirable; so that the addition could be built without any disarrangement of the present works.

Soaking-Pits.—The open-hearth ingots are carried in the moulds to the soaking-pits, where they are stripped by a hydraulic ingot-stripper and placed in the pits by the traveling-crane. There are three soaking-pit furnaces, holding 12 ingots each. The lids are moved by hydraulic power. After the ingots are thoroughly heated, they are taken out and placed on a tilting-car, which delivers them to the table of the blooming-mill.

Blooming-Mill.—The mill is two-high, with rolls 40 in. in

diameter by 103 in. in length, driven by a pair of 40- by 60-in. reversing-engines, built by the Wm. Tod Co. of Youngstown, Ohio. The engines are geared 1 to 2, with cut-steel gears. The top roll is moved by an engine placed on the top of the housings, which operates housing-screws by means of cut-worm and gear. The top roll and spindles are balanced by hydraulic pressure. The mill is provided with tables on both sides, and has two "manipulators," by which the blooms are turned and handled. The tables are of such length as to permit the rolling of from 75- to 90-ft. lengths.

Shear.—An extension of the blooming-mill table on the catcher's side brings the product to a powerful hydraulic shear, designed to cut blooms to 200 square inches, or 20 in. or 10 in. This shear is so designed that the consumption of water will be proportional to the work performed. Room is provided for another powerful shear, to cut small pieces, such as slabs for the plate-mill and billets for the merchant-mills.

Roughing-Mill and Heating-Furnaces.—From the shear the product goes either directly to the roughing-mill, or, if it must be heated, to two Siemens reheating-furnaces, where the blooms are charged and taken out by two Collins patent charging- and drawing-machines.

These machines were built by the Morgan Engineering Co. The mill is two-high, with rolls of 32 in. in diam. by 78 in. in length, driven by a pair of 36- by 48-in. reversing-engines. These engines are geared 5 to 7, with cut-steel gears. The mill is built on the same plan as the blooming-mill, and has the same operating and balancing arrangement, tables and manipulators. A portion of the product can be finished in this mill, but the greater part will be sent to the finishing-mill.

Finishing-Mill.—This is three-high, reversing, with three stands of rolls of 28 in. in diam. and 66 in. in length, driven by a pair of 36- by 48-in. reversing-engines, geared 1 to 1, with cut-steel gears. Movable tables run along the face of the train, and allow the bringing of the steel to or from any of the three sets of rolls. This arrangement permits a wide range of product, as any set will finish a piece. The front part of these tables operates on a hinge to transfer the piece from one pass to another. This mill will finish rails of from 35 to 100 lbs. per

yard, and beams and channels from 4 in. to 24 in. in height. It will roll Z-bars, tees, angles, steel railroad-ties, tie-plates, squares and rounds—in short, will roll any shape, the area of which exceeds 4 sq. in. For smaller sizes, merchant-mills are contemplated.

Hot-Saw.—From the finishing-mill the material is delivered to a run-out which brings it to the hot-saw, and, after cutting, to the cooling-beds. Rails pass through a cambering-machine before reaching the cooling-beds. From the latter the material is conveyed by drags and delivered to the straightening-presses, shears, drills, and such other machinery as may be required for finishing. All this machinery is placed in a special building and operated by electric power. The finished material is loaded directly into cars. For beams and shapes, large beds are provided to cut and shape as may be desired by architects and builders.

Traveling-Cranes.—Each roll-train is provided with an electric traveling-crane built by the Niles-Bement Pond Co. They are designed to facilitate the handling of heavy parts, and especially the changing of rolls. The crane of the finishing-mill has 60 tons capacity, and is able to lift each stand of rolls, including the housings, and replace it with another stand. As the changing of rolls usually occupies from two to three hours, this feature, which reduces the time to from fifteen to twenty minutes, will be appreciated. The blooming- and roughing-mills have 20-ton cranes, which can lift one roll at a time; and, as the changing of these rolls is not frequent, extreme expedition is not so important. The output will be governed by the amount of steel delivered, but the capacity of these mills is such that they will roll the product of twelve open-hearth- or four blast-furnaces. In case the market warrants it, all that will be required will be the extension of the open-hearth and the blast-furnace departments, which is provided for in the plans.

Gas-Producers.—To supply gas to the open-hearth, soaking-pit and reheating-furnaces, sixteen 10 ft. Talbot producers are connected by underground flues with these furnaces.

Foundry.—The foundry is located parallel to the mills, in a steel-frame and brick building, 225 ft. long. The central span

is 60 ft. wide, with two bays of 30 ft. each. It contains two cupolas 72 in. in diameter, and a small one for melting brass and bronze. For melting special iron for strong castings, an 18-ton air-furnace is provided. There are four core-ovens, and a complete equipment of machinery for mixing sand, cleaning castings, etc.; also, a 30-ton and a 15-ton electric traveling-crane. The capacity of the foundry is 30 tons per day. It is intended to do all classes of work, from the smallest castings to those weighing 30 tons or more.

Machine-Shop.—The shop is likewise located parallel to the mills, in a building of the same character and dimensions as the foundry. It is equipped with two Niles electric traveling-cranes of 30 and 15 tons, respectively. Great care has been taken to select the best tools. Among these are: One 96- by 96-in. Niles plane; one 54- by 54- in. Pond plane; one 84-in. Pond boring-mill; one 51-in. Niles boring-mill; one 18-in. Niles slotter; one 60-in. Niles engine-lathe; one 48-in. Niles engine-lathe; one 32-in. Pond engine-lathe; two 40-in. Frank-Kneeland roll-lathes, and two 60-in. Frank-Kneeland roll-lathes. In addition to these, there are numerous small lathes, slotters, bolt-cutters, pipe-machines, and a full equipment of machine-shop appliances. With the exception of the roll-lathes, each of which is driven by an independent electric motor, the tools are placed in groups, each group having its motor. The pattern-shop contains wood-working machinery, such as planes, circular- and band-saws, etc.

This machine-shop is intended not only to build machinery for the mills, but also to do any class of work that may be demanded by mines, smelting-works, railroads and manufacturing establishments.

Forge.—This is a steel-frame and brick construction, 50 by 100 ft. in size, and within easy reach of the machine-shop and foundry. It has a 700-lb. and a 1700-lb. steam-hammer; also bolt-, nut- and rivet-machines, blower and ten forges, with the necessary heating-furnaces. Power is supplied by a 25-H.P. General Electric motor.

Power-Plant.—The central power-station, which is a steel-frame and brick building 56 by 150 ft. in size, contains, at present, two Harrisburg tandem compound-engines 17 by 27

by 16 in. in size, each directly connected to a 150-K. W. General Electric generator. Steam is furnished by two 250-H.P. Babcock and Wilcox boilers. The plans provide for trebling the power when circumstances shall warrant such enlargement.

Store- and Oil-Houses.—The store-house is a brick building with iron roof, 60 by 60 ft. in size and two stories high. The oil-house is also of brick, with an iron roof. They are designed to keep supplies for the mills, under the supervision and control of competent storekeepers.

Water-Supply.—Water is obtained from a large reservoir NE. of the works, and supplied from the same source as the city, and is conveyed to a well near the blowing-engine house of the blast-furnace. Two powerful pumps, each of 250,000 gallons daily capacity, lift the water to a stand-pipe, from which it is distributed under pressure to the blast-furnace and mills. The waste-water from the blast-furnace is carried back to the reservoir through an open ditch, and the large surface of the reservoir allows it to cool to the desired temperature for renewed use. To furnish the necessary pressure for the different hydraulic machinery, a special pressure-plant has been located between the roughing- and finishing-mills. Two hydraulic supply pressure-pumps deliver the water under a pressure of 500 lbs. per sq. in. into an accumulator, whence it is distributed to the various hydraulic machines. The waste from these machines is conducted to a tank, from which it can be used again. The waste which cannot be used again is carried off by a sewage-system.

Track-System.—A terminal has been located, to make connection with all the railroads entering Monterrey. Great care has been taken in arranging the track-system to facilitate the delivery of coal, coke and ore, and the shipment of products.

Extensions to Plant.—A structural shop for bridges and buildings; merchant-mills; and wire- and plate-mills, are contemplated in the near future.

The Mechanical Feeding of Silver-Lead Blast-Furnaces.

BY ARTHUR S. DWIGHT, SAN LUIS POTOSÍ, MEXICO.

(Mexican Meeting, November, 1901.)

FROM the latest and best literature on lead-smelting, little can be learned concerning the present state of the art of mechanical feeding in the United States. H. O. Hofman, in his *Metallurgy of Lead* (5th ed., 1899), briefly describes the main features of the system in use at Pueblo, Colo., and later (p. 235) says "the only successful mechanical feeding, as far as the writer is aware, is that found at the works of the Pueblo Smelting and Refining Co."

H. F. Collins, in his *Metallurgy of Lead and Silver* (London, 1899), covers American practice pretty thoroughly; but as to mechanical charging, he says:

> "The German plan of taking off the gases by means of a small iron pipe suspended in the center, and the plan of charging by means of cup and cone, as in iron blast-furnaces, have both been tried, but have not found favor, chiefly on account of the difficulty of obtaining free access to the furnace-shaft for barring, etc., with such devices."

H. W. Hixon, in his *Notes on Lead and Copper Smelting* (3d ed., New York, 1900), gives a description and drawing of the Hixon feeding device, as originally installed at East Helena.

Evidence that this system of feeding has passed its experimental stage, and deserves more serious consideration than it has heretofore received, is furnished by two large plants—the Pueblo and the East Helena—of the American Smelting and Refining Co., where mechanical feeding has been in continuous and successful operation for a considerable period; one new plant now erecting at Salt Lake City, Utah, and one old one belonging to the same company, the El Paso works, now being rebuilt after a disastrous fire, in both of which mechanical feeding is to be a prominent feature; one new plant of an independent concern at Torreon, Mexico, which will adopt mechanical feeding; and a number of other smaller plants, among

which the Granby Consolidated Mining Co., British Columbia (a copper smelter), deserves mention.

It is the purpose of this paper to call attention to the present state of the art, to describe those devices which have come under the personal observation of the writer, and to record the results of some of his own studies and experience in connection with the practical working-out of one of these systems.

The underlying principles have long been recognized and followed in the metallurgy of iron; but as these need considerable adaptation to meet the peculiar requirements of lead-smelting, it is believed that a fresh discussion may be useful as a beginning of a proper understanding of the subject.

Dumping material into a furnace, haphazard, cannot be regarded as feeding in the proper sense. We must appreciate the effect of the mechanical arrangement of the smelting-column upon the blast-furnace reactions, before we can intelligently design a mechanical feed. Hence it is thought best to lead up to the special subject through a discussion of the general subject of feeding, both theoretical and practical, calling attention to certain minutiæ of the process, which, if overlooked, as has often been done, will probably cause a total failure, but which may be utilized to bring about exactly the effect desired.

I. Type of Furnace.

Let us assume that the furnace to be fed is the well-known rectangular blast-furnace developed by smelting practice in the Rocky Mountain region of the United States. A modern furnace of this type would have an area at the tuyere-level of from 42 by 120 to 48 by 160 in.; an area at the top of the shaft of from 54 by 132 to 84 by 200 in., and a height from the tuyere-level to the top of the charge of from 15 to 21 ft., depending on various features of design, conditions of charge, etc.

Such a furnace should smelt from 80 to 200 tons of charge in 24 hours. By charge, I mean the total weight of ore and flux, but not including the coke, or slag that is resmelted. This slag, principally shells from pots, etc., requiring to be rehandled on account of the shots of matte and bullion which it may contain, usually amounts to from 20 to 60 per cent. of the charge. The fuel will be coke only, the consumption being

from 12 to 16 per cent. of the charge, and is burned at a blast pressure ranging from 1.5 to 4 pounds per square inch, the average, perhaps, being close to 2 pounds.

If the furnace is to be fed by hand in the old style, two methods are common for removing the furnace-gases. They may be taken off by an opening below the charge floor, and in this case the furnace will be fed through a slot in the iron floor-plates, about 20 in. wide and extending nearly the whole length of the furnace; or the furnace-shaft may be extended as a hood above the charge-floor level, with a down-take pipe connecting it with the flues. In the latter case, doors are provided on each side of the brick or sheet-iron hood, extending preferably the whole length of the furnace, and usually having a sill, a few inches high, which compels the feeder to lift the material in his shovel, instead of dumping or shoving it carelessly into the furnace in the easiest way.

II. Mechanical Conditions of the Smelting-Column as Affecting Blast-Furnace Reactions.

When a silver-lead blast-furnace is operating satisfactorily, the following conditions should obtain:

1. A large proportion of the lead in the charge should appear as direct bullion-product at the lead-well.
2. The slag should be fluid and clean.
3. The matte should be low in lead.
4. The furnace should be cool and quiet on top, making a minimum quantity of lead-fume and flue-dust, and the charges should descend uniformly over the whole area of the shaft.
5. The furnace-speed should be good.
6. The furnace should be free from serious accretions and crusts; that is to say, the tuyeres should be reasonably bright and open, and the level of the lead in the lead-well should respond promptly to variations of pressure, caused by the blast and by the height of the column of molten slag and matte inside the furnace—an indication that ample connection exists between the smelting column and the crucible.

In common parlance, we shall have "good reduction" when the first three of these conditions are satisfied; and, in a general way, it may be said that the degree in which they are fulfilled is an index of successful operation.

I shall employ this convenient, though perhaps unscientific, use of the term "reduction," in expressing the degree in which the furnace is manifesting its reducing-action, as measured by the three conditions above mentioned.

For any given furnace there are five prime factors, the resultant of which determines the reduction, namely:

(a) Chemical composition of the furnace charges;

(b) Proportion and character of fuel;

(c) Air-volume and pressure, to which might perhaps also be added temperature of blast; for, although hot-blast has not yet been successfully applied in lead-smelting practice, the writer believes it is only a question of time when it will be;

(d) Dimensions and proportions of smelting-furnace;

(e) Mechanical character and arrangement of the smelting-column.

A thorough analysis of these five factors would constitute an exhaustive treatise on blast-furnace phenomena, which it is not intended to cover in this paper. That apparently simple, almost crude contrivance, the blast-furnace, offers to the investigator a problem involving an endless complexity and correlation of forces and conditions acting together in the most subtle adjustment. To disturb one condition is likely to produce an entirely unexpected result, which it will be very difficult to trace back to its cause. False reasoning is thus due to careless observation, and has inspired many metallurgical dogmas which are a real impediment to clear vision and intelligent progress.

The study of the phenomena of the lead blast-furnace is a rich field, as yet but very imperfectly exploited. The studies of the iron blast-furnace by Bell, Gruner and others, and Schertel's studies of the Freiberg furnaces, give us a good beginning, but still only a beginning. We have to deal with reactions entirely different from those prevailing in the iron-furnace. Some of our metals must be reduced and some oxidized; and to steer a course through the many conflicting currents of oxidation and reduction, and, by adjusting the relative importance of the various agents at our command, secure just those reactions most favorable to a good outcome, is the problem of the lead-smelter.

Returning to the five controlling factors of reduction, it will

be observed that all but one are susceptible of mathematical expression, and their variations can be intelligently gauged. Thus we can accurately establish the composition of the charge by the weights and analyses of its ingredients; the fuel by its weight; the blast-volume by engine-measurement, and its pressure by the reading of a mercury-gauge, while the variable component of the furnace-factor can be expressed by the height in feet of the smelting-column. The mechanical factor, however, can be expressed only in generalities and most indefinite terms. To regulate it we can do much beforehand by a wise selection of ores and by intelligent preliminary preparation, crushing the coarse and briquetting the fine; but when all this has been done, our efforts are largely nullified by the uncertain human element in the feeding. Even with conscientious workmen, the necessarily divided responsibility does not tend to regularity of results, particularly when each feeder has his own theories, and thinks he knows, better than the superintendent, what is wanted. In certain aggravated cases of improper feeding there is no difficulty in recognizing the symptoms; but there remain numerous variations, springing from irregularities, the causes for which are obscured, and which we are prone to attribute, therefore, to mysterious or fortuitous circumstances. This no doubt explains why we so generally take it for granted that the feeding is right, and devote our chief attention to the manipulation of those factors which can be mathematically regulated,—the slag, the fuel, and the blast,—while the importance and possibilities of the mechanical factor are generally overlooked, and its symptoms are wrongly diagnosed.

For instance, the importance of slag-types has undoubtedly been considerably exaggerated at the expense of the mechanical factor. Slags will seldom come down exactly as figured. We must know our ores, and apply certain empirical corrections to the iron, sulphur, etc., based upon our previous experience with these ores. The necessity of such allowances is due partly to variations in weights and moisture, analytical errors, etc.; but I venture to suggest that these empirical corrections represent also an unformulated expression of the influence of the mechanical factor on the reduction,—a function, therefore, of the ruling physical complexion of the ores, and the peculiarities of the feeding habitually maintained in the works concerned.

Unquestionably the careful regulation of the slag is one of the foundations of good blast-furnace work; but it is not only, or always, the most important one. With a given ore-charge, large reciprocal variations may be produced in the composition of the resulting slag and matte by merely changing the mechanical conditions of the smelting-column; and since the efficient utilization of both the fuel and the blast must be controlled in the same way, we are justified in considering the mechanical factor as perhaps the dominating agent of reduction in the lead blast-furnace. Hence the importance of keeping the closest regulation upon it will be clear. But as we have no means for mathematically gauging it, our only recourse is to seek a correct adjustment, and then, by eliminating all uncertain elements, maintain it as a positive constant. With the dominating factor thus brought under control, we can, with much greater certainty, adjust the slag, fuel and blast, with a resulting gain in efficiency of furnace-work and metal savings.

III. The Reduction of Iron, the Key to the Process.

While it is true that a proper saving of lead is one of the chief ends of the process, it is, nevertheless, a fact that the output of lead is so dependent upon the behavior and reactions of the iron that we would do well to fix our chief attention upon that metal as the key to the situation. In short, the success of the process very largely depends upon reducing just the right amount of nascent Fe to throw the Pb out of the matte, while the rest of the iron is reduced only to FeO and enters the slag. Too much Fe reduced will form an iron-sow in the hearth. With a given ore-mixture, slags of varied composition may be produced by simply changing the degree of oxidation or reduction prevailing in the furnace; and this we may regulate by means of the various agents at our command, already referred to.

On account of its ready susceptibility to reducing influences, lead in the slag or matte affords a most sensitive index of the degree of reduction in the furnace. The lower the percentage of lead in these products, the greater the reduction indicated.

There are two principal reactions by which the reduction of iron from its oxides is accomplished in the blast-furnace: (1) by contact with solid incandescent carbon; and (2) by the action of hot reducing-gases, principally CO.

In actual working, we doubtless always get a resultant of both modes of reduction, acting simultaneously; but it is possible to make one or the other strongly predominate, and give character to the entire process. We know that reduction by solid carbon is much the more wasteful of the two; however, outweighing in importance this loss of fuel-efficiency, there is in lead-smelting a far more serious objection to permitting the reduction to be accomplished by this means. Since this presupposes that both reduction and fusion shall be accomplished within a zone of incandescence, and since reduction must necessarily precede fusion, the combustion of the fuel must be carried high up in the shaft, leaving less room for the absorption of the heat of the escaping gases. This means a comparatively hot top, and more or less volatilization of lead.

On the other hand, the second mode of reduction is the ideal condition for the lead-furnace. It means keeping the zone of incandescence low in the charge-column, leaving plenty of room above for the gases to yield up their heat and reducing-power to the descending charge, so that by the time they escape at the charge-floor level they will be well-nigh spent; temperature and volume will be diminished; and the low velocity of exit will tend to minimize the loss of lead in fume and flue-dust.

The opinion expressed by some writers that high temperatures in lead-furnaces should be avoided is based on a misconception. In any case, temperatures must exist which are sufficiently high to volatilize all the lead in the charge, if other conditions permit. A high temperature before the tuyeres, moreover, means fast smelting; and fast smelting, under proper conditions, means a shortening of the time during which the lead is subject to scorifying and volatilizing influences. Again, a rapidly-descending column of charge, constantly replenished with cold ore on the top, serves to absorb effectively the heat and reducing-power of the gases, and acts as a most effective dust- and fume-collector. It may truly be said, in considering the question of long flues, bag-houses, and other adjuncts for saving metals, that the most efficient of all dust-collecting apparatus ought to be the furnace itself.

In the practice of twelve years ago and earlier, particularly when using fuel-charges of mixed coke and charcoal, reduction by carbon was probably the rule; and, as is well known, the

fuel-percentage then required was very high. There is good reason to think that we have still much room left for improvement along this line in our average practice of to-day.

Analyses of the waste gases would, perhaps, furnish a good test of fuel-economy. Indeed, I have made many such analyses, with significant results, which I am not now prepared to discuss.

IV. Volume and Pressure of Blast.

1. *Volume.*

It is customary in smelter-practice to supply a battery of furnaces from a large blast-main, connected with a number of blowers. As the blast-currents will always give preference to the lines of least resistance, it is evident that we have only to increase the internal resistance of any one furnace in the battery to diminish considerably the volume of air that furnace will take, while the others will be favored unduly. Only by keeping all the furnaces on approximately the same charge, and with the same height of smelting-column, can we secure anything like uniformity of operations and close regulation in all. The truly rational plan would seem to be, to have a separate blower of variable speed, directly connected to each furnace, so that the volume of air delivered could be gauged by the revolutions of the blower. This plan of direct connected blowers has received a number of trials, but usually has been abandoned in favor of the common blast-main. The writer's own experiments in this direction, on several different occasions, with trials extending over considerable periods, have been so uniformly favorable that he is forced to ascribe the failure of other attempts of the kind to some outside reason,—probably lack of proper modification and adaptation of the other smelting-conditions.

The peculiar atmosphere of reduction required for lead-furnaces depends upon a correct relative proportion of the two counter-active elements, carbon and oxygen. If too much air is supplied, the balance will be disturbed, and the furnace will show signs of deficient reduction, which will commonly be interpreted as calling for more fuel. This extra fuel, however, will be a sheer waste, as its object is to burn up surplus air. There is a double waste, therefore,—of coke in the furnace and

of coal under the boiler. In this hypothetical case the true remedy would evidently be to cut down the quantity of air.

To get the highest efficiency out of our furnaces, we must relieve them of all unnecessary work. Burning up excessive coke and air is as hard work as smelting ore. Too much fuel invariably slows up a furnace; it also drives the fire upwards in the stack, and gives predominance to the reduction by solid carbon. The maintenance of a minimum fuel-percentage, with a correctly-adjusted volume of air, will therefore tend to promote the conditions under which iron will be reduced by the gases, rather than by solid carbon, and will favor furnace speed.

2. *Pressure.*

It is necessary to make a clear distinction between the volume and the pressure of the blast, and to recognize that distinct effects can be produced by intelligently varying these two factors independently. I have shown the importance of securing a proper adjustment of the volume; the question of pressure will now be considered.

Pressure necessarily involves resistance; and the blast-pressure, as registered by a simple mercury-gauge on the bustle-pipe, may be increased in two ways:—

First: By increasing the volume of air forced through the interstices in the charge. This is the wrong way; but, unfortunately, it is only too common in our practice, and therefore deserves to be mentioned, if only to be condemned.

Second: By leaving the volume of air unchanged, but increasing the friction offered by the interstitial channels, either by making them smaller in aggregate cross-section (which means a finer charge), or by making them longer (which means a higher smelting-column). A correctly-graduated internal resistance is, therefore, the only true basis for a high blast-pressure, which, when so produced, will bring about rapid smelting, a low zone of incandescence, and a very vigorous action upon the ores by the gases in their retarded ascent through the charge-column. These conditions promote the reduction of iron by CO. The adjustment of internal resistance, which is thus clearly the main factor, can only be accomplished by the correct feeding of the furnace.

V. The Mixing of Charge-Ingredients.

It is self-evident that the more thorough the preliminary preparation of the charge before it reaches the zone of fusion, the more rapidly can the actual smelting proceed. A piece of raw ore that finds itself prematurely at the tuyeres, without having been subjected to the usual preparatory processes of drying, heating, reduction, etc., must remain there until it is gradually dissolved or carried away mechanically in the slag. Any such occurrence must greatly retard the process. It would seem, by the same reasoning, that an intimate mixture of the ingredients of the charge should expedite the smelting. On this point I must differ from the conclusions of Henrich,* who advocates a system of feeding which shall deliberately avoid an intimate mixture of ingredients, the idea being to prevent the premature formation of a slag in the upper regions of the furnace. My experience leads me to believe that there is no danger of this premature slag-formation if the furnace is smelting properly, and that to follow Henrich's procedure would be merely to treat one of the symptoms without striking at the root of the evil. I therefore advocate the intimate mixture of the charge-ingredients in all cases.

VI. Mechanical Arrangement of the Charge-Column.

The theory of feeding is exceedingly simple; and if the practice were as easy as the statement of the principle, this discussion could be considerably abbreviated. If the charge-column were composed of particles of uniform size, the ascending gases would encounter the least resistance close to the furnace-walls, and consequently would travel by that route in preference to the central portion of the shaft. This more restricted channel would necessitate a higher velocity, so that not only would the charge in the central portion be largely deprived of the benefit of the heat and reducing-action of the gases, but the portion traversed would be overheated; many of the particles would be sintered to the walls or carried off as flue-dust; slag would form prematurely; a large part of the fuel would be wasted, causing a dissipation of the metal-values;—in short, all the

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* *Engineering and Mining Journal*, December 27, 1890, and June 6, 1891.

grave irregularities and losses would ensue which accompany over-fire.

In actual practice, the charge is never perfectly uniform, but is a mixture of relatively coarse and fine material. This gives us the means of correcting the tendency of the gases to follow the walls by classifying the charge, and lodging the finer particles close to the walls and the coarser in the center. The correct adjustment will be found when the current of gases is forced to ascend uniformly over the whole area of the smelting-column; and we may say, in brief, that a furnace-top uniformly and quietly smoking over its whole area is the visible sign of a properly-fed furnace.

On the other hand, no furnace in which the coarse is fed against the walls and the fine in the middle can possibly do good work. If the case is an extreme one, a disastrous condition will be rapidly brought about, which will soon terminate the campaign.

VII. Effect of Large Charges.

It has frequently been remarked that, within certain limits, large charges give more favorable results than small ones; and numerous attempts have been made to account for this fact. My observations lead me to offer the following as a rational explanation—at least in cases where ore and fuel are charged in alternate layers. Large ore-charges mean correspondingly large fuel-charges. The gases can pass readily through the coke; and hence each fuel-zone tends to equalize the gas-currents by giving them another opportunity to distribute themselves over the whole furnace-area, while each layer of ore subsequently encountered will blanket the gases, and compel them to force a passage under pressure, which is the manner most favorable to effective chemical action. The idea is somewhat similar to that of the "filter-charges" described by Glenn,* which probably owed their efficacy to the same cause.

An interesting observation may be made at this point. In hand-feeding it is customary to charge ore and fuel in separate layers, while in mechanical feeding by the charge-car they are usually dumped into the furnace simultaneously, and thus the separate layers are obliterated. A mechanically-fed furnace

* *Engineering and Mining Journal*, July 19, 1884.

will, therefore, lack the distributing zones, which are such a safeguard against the consequences of bad feeding in hand-fed furnaces; and hence it is that much more care must be exercised to secure a proper placing of coarse and fine material in the case of mechanical feeding—though the nearer perfection we can come in either case, the better operating-results we shall obtain. This may throw some light on the cause of the failure of most of the early attempts at mechanical feeding.

VIII. Effect of Mechanical Character of Charge.

Very fine charges blanket the gases excessively, and cause them to break through the layers at a few points. This leads to the formation of blow-holes or craters, which seriously disturb the operation, cause loss of raw ore in the slag, and are accompanied by all the evils of over-fire. A charge containing a few massive pieces, the rest being fine and pulverulent, is a still more unfavorable combination. On the other hand, a very coarse charge permits too ready an exit to the gases, but in the end tends likewise to over-fire and poor reduction.

While the opposite extremes of too fine or too coarse charges exhibit many similar symptoms in actual operation, they are to be cured by exactly opposite remedies: the former we must correct by briquetting a considerable portion (though, preferably, not all) of the fines; and the latter, by a preliminary crushing of the coarser material. Thus, from opposite extremes, we approach an ideal result, which we may roughly describe to be a mixture in which about one-third is pieces from 5 to 2 in. in diameter, one-third from 2 to $\frac{1}{2}$ in., and the remaining third from $\frac{1}{2}$ in. down. The coke is better for being somewhat broken up before charging, and a reasonable amount of coke-fines, such as usually accompanies a good quality of coke, is not in the least prejudicial. The common practice, therefore, of handling the coke by forks and throwing away the fines, is to be condemned as an unwarranted waste of good fuel. The slag on the charge should be broken to pieces at most 6 in. in diameter. The common practice of throwing in whole butts of slag-shells is bad; and there is no economy in using the slag hot, as some imagine. Cold charges, not hot, are what we want.

A reasonable amount of moisture in the furnace-charges is beneficial, provided it be in such form as to be readily dried out

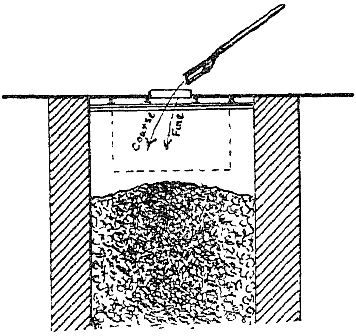
in the furnace. It is often advantageous to wet down the ore-mixtures while bedding them, or to sprinkle the charges before feeding to the furnace. It is true that driving off this water must consume fuel, but not so much as would be lost if the smelting-zone crept up in the shaft. Large doses of water applied to the furnace direct, facetiously called "hydraulic flux," are hardly pardonable under any circumstances, though they are sometimes indulged in as a drastic measure to subdue excessive over-fire, when other and surer means of curing the disorder are not recognized. One of the chief merits of moderately sprinkling ore-charges before feeding is, that it gives, in many cases, a more favorable mechanical character, approximating a lumpy condition in too fine a charge, and assisting to pack too coarse a charge.

IX. Different Behavior of Coarse and Fine.

When a dry mixture of coarse and fine material is handled or moved, it will be observed that the coarse and fine particles behave quite differently. When taken up in a shovel, the fine will predominate in the bottom and center, and the coarse on the top and sides; when thrown from the shovel, the coarse will outstrip the fine and fall beyond it. In building a conical pile, a very noticeable separation will take place, the coarse rolling to the base of the cone, leaving the fine nearer the apex. When thrown against a surface, the coarse will rebound, while the fine will not. Thus the coarse is mobile, while the fine is sluggish; and the former will take advantage of every opportunity, by crowding, bouncing and rolling, to separate itself from the less lively portion. This simple fact, once thoroughly appreciated, gives us the key to the practical side of the feeding-problem, both manual and mechanical. It is not sufficient to tell our feeders to throw the coarse in the middle and the fine against the sides; if it be easier to do it some other way, our instructions will count for but little. The principle of "least resistance" must be considered in the directing of labor, as in other branches of mechanics. A desired result can be best secured by making the right way easier for the workman than the wrong way. This may sound like a glittering generality; but it has a peculiarly practical bearing on the present subject. For instance, it is pretty generally conceded that the open-top

furnaces, fed by hand through a slot in the floor-plates, do not give as satisfactory results as the hooded furnaces with long

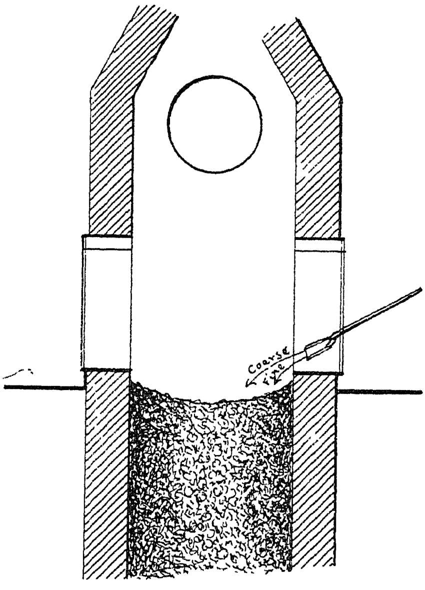
FIG. 1.



Open-Top Furnace; Central Feed.

feed-doors on both sides. Figs. 1 and 2 will perhaps suggest a reason for this preference. In the open-top furnace it is com-

FIG. 2.



Hooded Furnace; Side Feed.

paratively difficult to throw to the sides, the difficulty being greater as the slot is narrower. The greater part of the charge, therefore, will drop near the center, making that place higher

than the sides; the fine will tend to stay where it falls, while the coarse will tend to roll to the sides, or gradually be crowded in that direction as the charge descends in the furnace; and there will result just the reverse of the proper mechanical arrangement in the shaft. In the hooded furnace, on the other hand, most of the material will naturally fall near the doors as it is shoveled in, causing the sides to be higher than the center, while the coarse stuff rather favors the center by reason of the force of the throw—a tendency which will be increased by the fine remaining near the walls, and the coarse rolling and crowding toward the center, as the charge descends. Other conditions being equal, therefore, the hooded furnace will naturally be more correctly fed and will yield more satisfactory results.

X. The Future of Mechanical Feeding.

Once a proper balance of conditions has been found, absolute regularity of routine is the secret of good results. It has been shown how the main chemical reactions in the blast-furnace are modified and regulated by the feeding. Hence no feature of furnace-economy is more deserving of attention than this.

An experienced and intelligent feeder owes his merit to his conscientious regularity of work. He may have to vary his programme somewhat when he encounters a furnace that is suffering from the results of bad feeding by a predecessor; but his guiding principle is first to restore regularity, and then maintain it. A poor feeder can bring about, in a single shift, disorders that will require many days to correct, if indeed they are corrected at all during the campaign. The personal element is productive of more harm than good.

The sweeping statement that the hand-fed furnace, normally operating, is properly fed in proportion as the feeder, faithfully following a well-ordered programme, approximates the regularity of a machine, is not far from the truth. Why not, then, eliminate entirely the personal element, and design a machine for the purpose? This is a comparatively simple matter, if we know exactly what we want to accomplish. The mysteriously potent virtue popularly attributed to hand-work of all kinds we can dismiss, without much discussion, as the oft-repeated argument of the opponents of progress since the first introduction of machinery. No one will deny that the desired regularity of

system can be attained more perfectly by a machine than by a human being, and thus the primary feature will be secured. Admitting that irregularities are bound to occur from lack of adjustment of fuel, blast, composition of charge, etc., even with the most perfect feeding, these irregularities can usually best be treated by removing their cause, while the feeding is kept absolutely uniform. However, if it is deemed desirable, it is still perfectly feasible to modify temporarily the action of a mechanical feed by various expedients, and thus, perhaps, assist in restoring the normal condition. Human intelligence may still have just as free a scope with mechanical feeding as with hand-feeding, to adjust and correct; but with a well-adjusted feed, the less variation is indulged in, the better.

No valid ground now exists for prejudice against mechanical feeding in lead-smelting. As has already been explained, it is in successful operation in a number of large works, and is being installed in others. The fact is, and must be clear to any one in close touch with actual conditions, that our furnaces have outgrown the shovel, and we have passed the limit of efficiency of the old methods of handling material for them.

The tendency of modern progress has been to concentrate the business of smelting at a comparatively few plants, centrally located with respect to ore- and fuel-supplies, and favored with ample railroad-facilities. This tendency has been emphasized by recent industrial consolidations whereby the silver-lead smelting business of the United States and Mexico has passed into comparatively few hands. The logical outcome will be the introduction of labor-saving machinery and methods, not merely for the purpose of reducing operating-expenses, but also by reason of the physical necessities consequent upon crowding the capacity of single plants.

There is no need, therefore, to plead the cause of mechanical feeding. We must come to it in spite of ourselves. I wish to make the point, however, that whatever motive may lead to its introduction (a desire to reduce operating costs, scarcity of labor, limited space, etc.), its chief justification will be discovered, after it has been successfully installed and correctly adjusted, in the consequent great improvement of general operating-results, metal-savings, etc. It will remove one of the most uncertain factors with which the metallurgist has to deal,

thereby bringing out into clearer view for study and regulation the other factors (fuel-and-blast proportion, slag-composition, etc.) in a way that has hardly been possible under the irregularities consequent upon hand-feeding.

XI. Historical.

This paper is intended, not to give a full history of mechanical feeding in lead-smelting practice, but merely to discuss some of the attempts to solve the problem which have come under the observation of the writer. These will be considered separately, by classes.

(a) *Cup-and-Cone Feeding-Devices.*—So far as I am aware, the first lead-furnace in the United States fed by means of the cup-and-cone system was the round furnace of the St. Louis Smelting and Refining Co., at St. Louis, Mo., which I saw in operation about 1888. It is probable, however, that previous attempts had been made to follow German practice, as exemplified in the Pilz furnaces at Freiberg and the copper-furnaces at Mansfeldt; for Hahn, writing in 1882,* refers in a general way to unsuccessful experiments with the cup-and-cone feeder, which failed because the heat crept up in the furnace and gave over-fire. At the time of my visit to the St. Louis works, the furnaces chanced to be showing signs of over-fire; but this may not have been their characteristic condition.

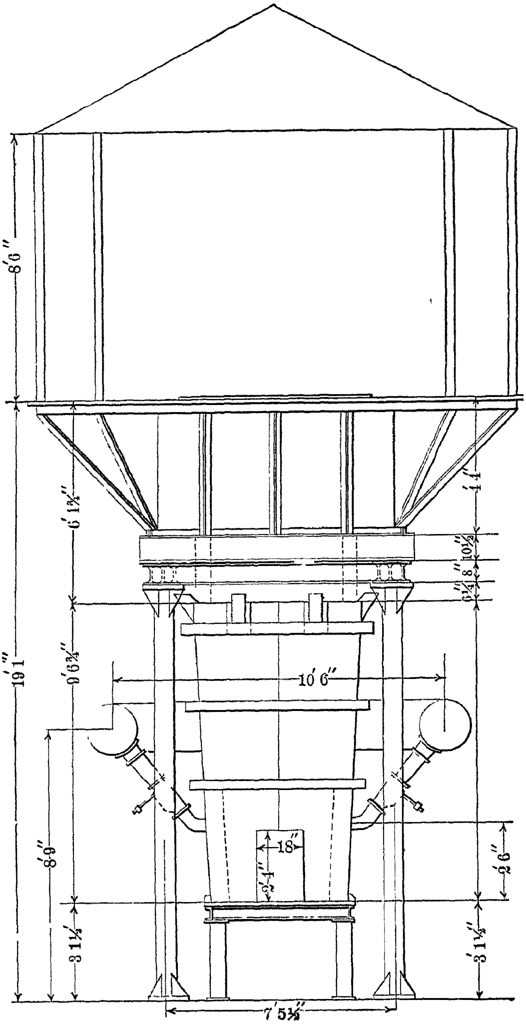
Mr. A. F. Schneider, who built the St. Louis furnaces, afterwards built, at the Perth Amboy (N. J.) works of the Guggenheim Smelting Co., round furnaces, with cup-and-cone feeders, which were probably quite similar to the earlier furnaces at St. Louis. Good results are said to have been obtained from these furnaces; but the running of refinery-products is not a good criterion of what they would do on general ore-smelting.

The cup-and-cone is an entirely rational feeding-device for a furnace of circular cross-section, and it certainly ought to be possible to adjust it so as to give as satisfactory results in lead- as in iron-smelting; but it is unquestionably unsuitable for a furnace of rectangular cross-section. Figs. 3 and 4 show such a furnace (original Aguascalientes copper-furnace), provided with two sets of circular cup-and-cone feeders. Disastrous re-

* *Mineral Resources of the United States*, Washington, 1883.

sults followed the use of this device on lead-furnaces; and the reason will be clear when it is considered that the circular distribution so given cannot possibly conform to the requirements

FIG 3.

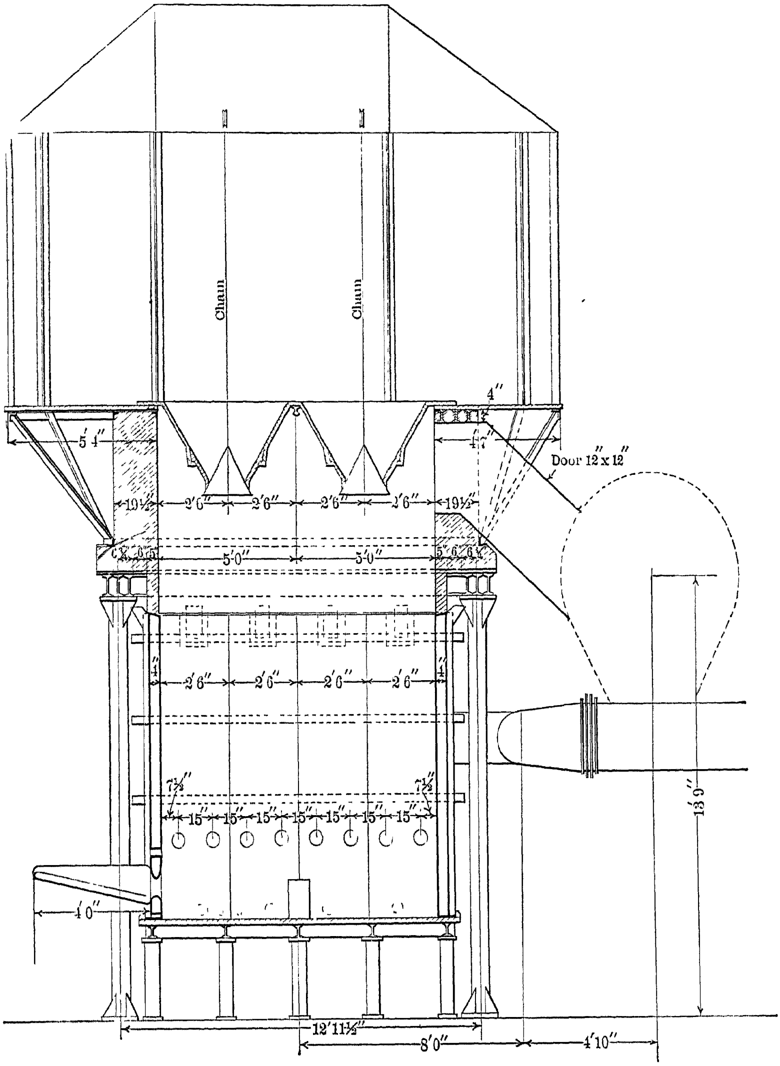


Original Type of Aguascalientes Copper-Furnace. Front Elevation.

of a rectangular furnace. Figs. 5 and 6 show a more rational plan of bell-and-hopper feed for such a furnace. It was designed for the Perth Amboy works, but details are lacking as to its record.

(b) *Pfort Curtain or "Thimble."*—About ten years ago some of the American works adopted the Pfort curtain, which was used in Germany as early as 1842 for feeding iron-furnaces.

FIG. 4.

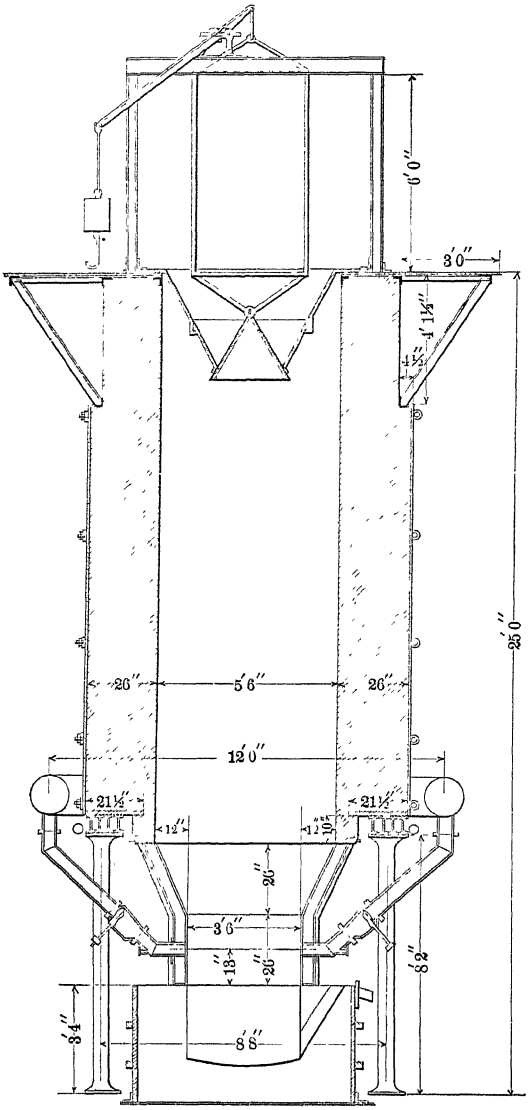


Original Type of Aguascalientes Copper-Furnace. Vertical Section from Front to Rear.

As adapted to lead-furnaces, it consisted of a thimble of sheet-iron hung from the iron deck-plates, so as to leave about 15 in. of space all around between it and the furnace walls, which

space, being connected with the down-take of the furnaces, served to collect and carry off the gases. In use, the thimble

Fig. 5.

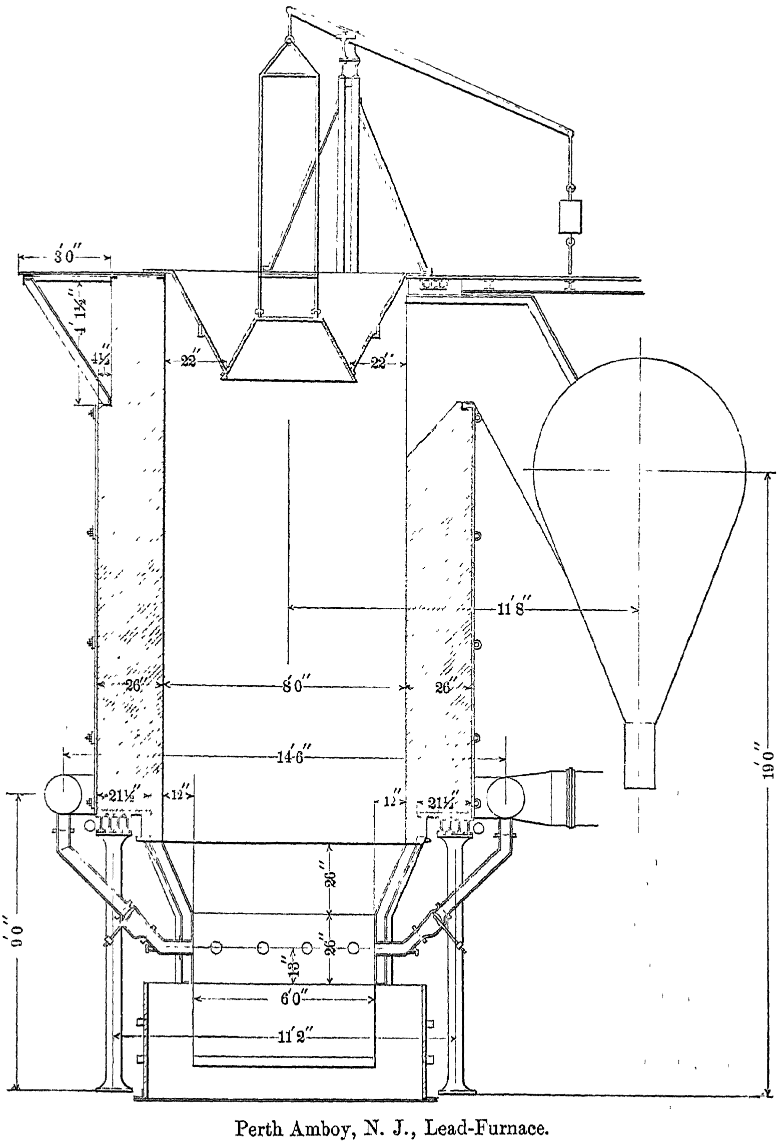


Perth Amboy, N. J., Lead-Furnace.
Vertical Section, at Right Angles to Fig. 6.

was kept full-charged up to the level of the charge-floor. For a time it was a very popular feeding-device, because it made a

neat appearance on the charge-floor, prevented smoking of the furnace, and considerably diminished the actual labor of feed-

FIG. 6.



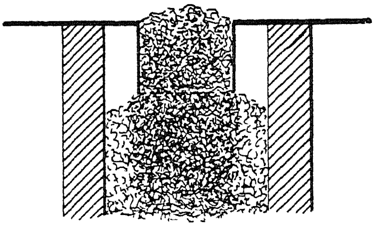
Perth Amboy, N. J., Lead-Furnace.
Vertical Section, at Right Angles to Fig. 5.

ing. Fig. 7 shows the arrangement as used by the Omaha and Grant Smelter, Denver, Colo.; the El Paso Smelting Works,

El Paso, Tex., and the refinery of the Consolidated Kansas City Smelting and Refining Co. at Argentine, Kans. It was finally found to give bad results in the furnaces, and was discarded everywhere.

H. O. Hofman* gives as his reasons for its failure, "first, that it was impossible to see how the charge sunk, except by dropping it below the edge of the thimble; and, second, that the time for barring down wall-accretions was lengthened, because it was necessary to remove the curtain before, and put it back again after, barring." Although these reasons are important, there was another considerably more important, namely, the thimble caused irregular furnace-work and high metal-losses, because it produced in the smelting-column a distribution of coarse and fine exactly the reverse of correct.

FIG. 7.



Pfort Curtain.

Moreover, by taking off the gases close to the walls of the furnace, it emphasized the evil by inducing them to follow up the walls directly from the tuyeres, without permeating the smelting-column to its center.

(c) *Terhune Gratings.*—R. H. Terhune has patented† a device for securing a proper distribution of coarse and fine in the furnace, which consists of two inclined "grizzlies" or gratings, one on each side of the furnace, sloping downward from the edge of the charge-floor toward the center-line of the furnace. The bars of the grizzly are tapered toward the center of the furnace, leaving the open spaces narrow near the furnace-walls and wider toward the center; so that, as the charge is dumped on the grizzly from the side of the furnace, a classification of the sizes will be effected as the charge slides down the grizzly,

* *Metallurgy of Lead*, 5th edition, page 234.
† U. S. Pat. No. 585,297, June 29, 1897.

and, as a result, the particles of smallest diameter will be deposited near the walls, and those of the largest diameter in the center. While correct in its conception, this device has not been actually used in practice, so far as I know.

I will now describe in detail the systems of Pueblo and East Helena, as the two most important installations now in operation, and indicative of the present line of development in this branch of the art.

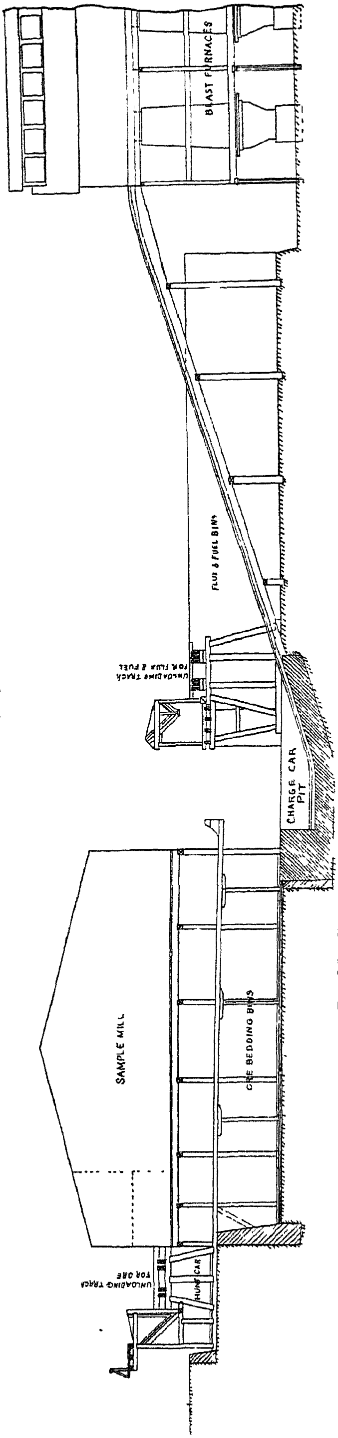
XII. The Pueblo System.*

The Pueblo Smelting and Refining Co., now known as the Pueblo plant of the American Smelting and Refining Co., was probably the first of the large lead-smelting concerns in the United States to practice mechanical feeding with any marked degree of success. Under the direction of Mr. W. W. Allen, then General Manager, an entire remodeling of the plant was undertaken, providing for the cheap handling of material in a manner far in advance of anything that had yet been attempted in lead-smelting. The mechanical feeding of the blast-furnaces was an essential feature of the general scheme, and deserves recognition, as practically the first successful device of this kind on a large scale, and the prototype of that class of feeding-devices which uses a large car. It was put into operation about 1895; and the following description will give a general idea of the system in operation about two years ago, since when, presumably, no serious change has been made.

The Pueblo furnaces have a cross-section at the tuyeres of 60 by 120 in. The tuyeres, 4 in. in diameter, are arranged six on each side, with water-cooled nozzles projecting 6 in. inside the jackets, thus leaving a distance of 48 in. across the furnace between tips of tuyeres. The height of smelting-column above tuyere-level is about 20 ft. The furnace-gases are taken off below the charge-floor, and the furnace-tops are closed by simple hinged and counterweighted doors of heavy sheet-iron, which can be opened by the attendant just previous to dumping the charge-car. In the side-walls of the shaft are iron door-frames, bricked up while the furnace is in operation, but permitting, when necessary, the repairing or barring-out of the shaft, without interfering with the movements of the charge-car

* U. S. Pat. 554,562, Feb. 11, 1896. H. G. Williams.

Fig. 8.



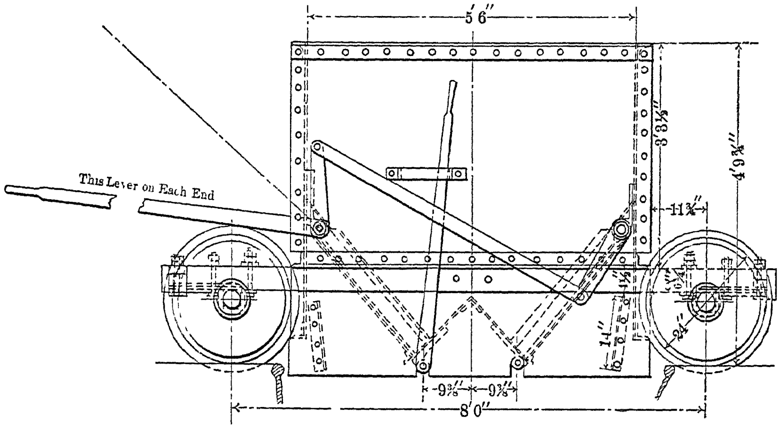
Pueblo System: Longitudinal Vertical Section through Incline.

overhead. Extending across the shaft, about 18 in. above the normal stock-line, are three A-shaped cast-iron "deflectors," dividing the area of the shaft into four equal rectangles. The purpose of these deflectors will be explained presently.

Fig. 8 is an ideal vertical section through the ore-bins and blast-furnaces, showing plainly the general arrangement. Figs. 9, 10 and 11 give the charge-car in detail, and Fig. 12 indicates the scheme of feeding. From the charge-car pit, conveniently located between the ore-bins and the fuel- and flux-bins, there extends an inclined trestle-track on an angle of 17° to the level of the charge-floor of the furnace-building, in line with the battery of furnaces. The gauge of this track is approximately equal to the length of the furnaces at the top. The charge-car, actuated by a steel tail-rope, moves sideways on this track from the charging-pit to any furnace in the battery. The hoisting-drums are located at the crest of the incline within the furnace-building, so that the attendant can have a view of the car at all times. At the far end of the furnace-building is a tightener-sheave, with a weight to keep proper tension on the tail-

rope. The charge-car has a capacity of five tons, with an A-shaped bottom; so that, in discharging, the material is divided

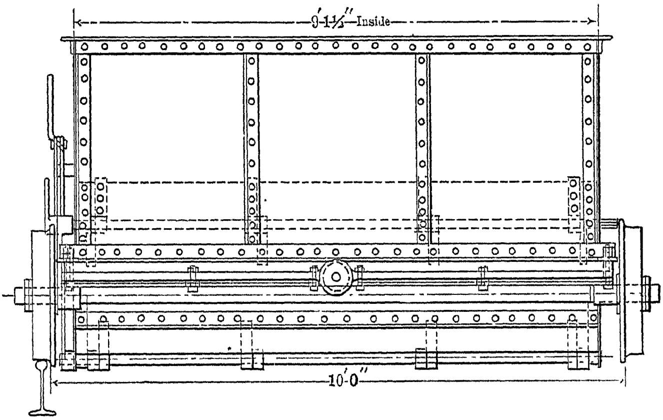
FIG. 9.



Pueblo Charge-Car. Side Elevation.

and thrown well against the side-walls of the furnace. The locking-mechanism of the car is arranged with levers, so that one attendant can quickly trip the bolt and discharge the car.

FIG. 10.

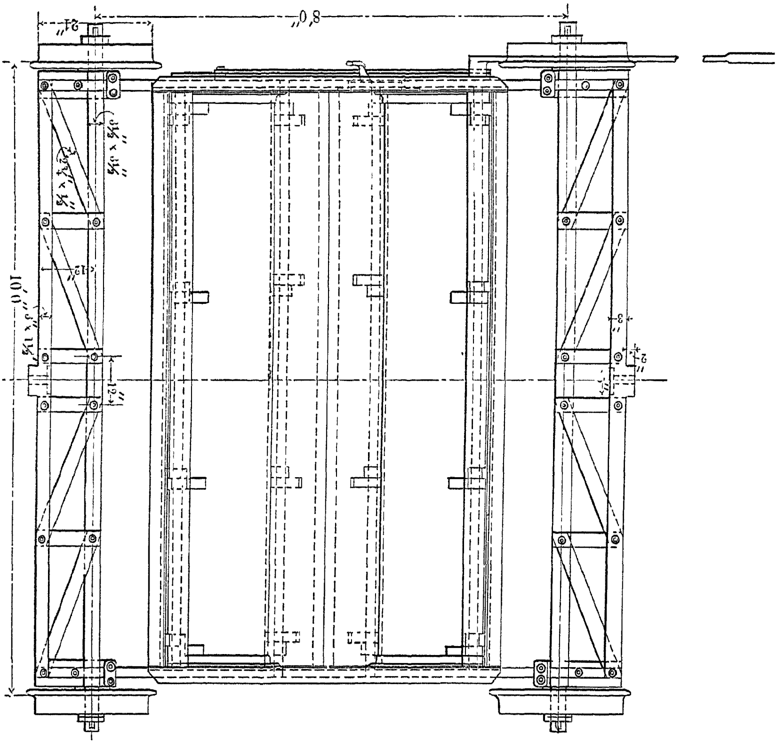


Pueblo Charge-Car. End Elevation.

While the car is making its trip to the furnace, the charge-wheelers are in the bins, filling their buggies. They work in pairs, each man weighing up in his buggy one half-charge of

a particular ingredient. They then separate, each taking his proper place in a line of wheelers on either side of the charging-pit, awaiting the return of the car. When it has returned to position, the wheelers successively discharge their buggies into the opposite ends of the car, partners thus discharging equal quantities of the same ingredients simultaneously, until the charge is complete; the coke being added last, to avoid crush-

FIG. 11.

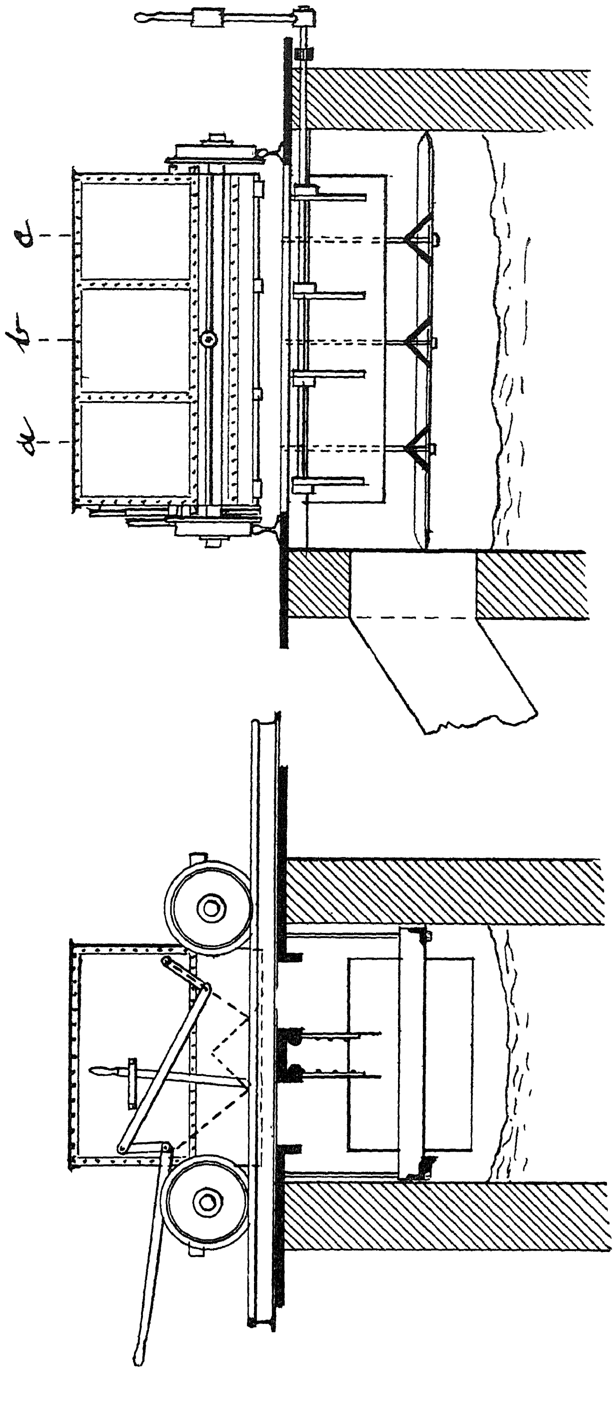


Pueblo Charge-Car. Plan.

ing it. The car can thus be very quickly filled, if plenty of wheelers are provided, to be always ready with their loads when the empty car returns. This involves, however, more wheelers than would be actually required merely to move the material to the best advantage; for they have not only to move the material, but also to wait for the car, and for their proper turn. The system is, therefore, not strictly economical of labor.

A vertical section through the car thus filled by dumping

FIG. 12.



Pueblo System: Sectional Diagrams of Furnace-Top.

from the two ends will show an arrangement of coarse and fine material far from regular. Analyzing its structure, we shall find two conical piles near the ends, each with a core of fine stuff, in line with a and c (Fig. 12), while in the valley between these piles is a miscellaneous collection of coarse and fine, with the coarse distinctly predominating in the center of the car (b.) The use of the A-shaped cross-deflectors will, therefore, be clear. Being set directly under the average position of the cores of fine stuff, they serve to scatter the fines as they drop from the charge-car. Thus, by the A-shaped bottom of the car, the charge is thrown against the walls, while by the A-shaped cross deflectors the irregularities of longitudinal arrangement of material are to some extent corrected. There can be no doubt that without these deflectors the feeding of the furnace would be a failure. Although a sort of compromise, it is nevertheless successful.

Two years ago, when I last saw these furnaces, there was a decided tendency to run rather hot on top; and that this was quite persistently the case seemed probable from the fact that the practice at that time was to put as many as three charges in rapid succession into the furnace, so as to cool the stack and carry down the over-fire. It is therefore reasonable to suppose that the feeding was not as perfect as it might be.

The saving effected by mechanical feeding at the Pueblo plant over the old system of hand-feeding is $63 per day, including the cost of steam, but not wear and tear on machinery. This estimate is based on running the entire battery of 7 furnaces at the average daily tonnage of 100 tons ore per furnace-day, and the saving is therefore 9 cents per ton of ore. This is distinctly a maximum figure; and, with fewer furnaces running, the fixed charges of the mechanical feed would soon increase the cost per ton to such a point that the two systems would be about equal in economy.

XIII. The East Helena System.

While visiting in a consulting capacity, two or three years ago, the East Helena, Montana, plant of the American Smelting and Refining Co. (then belonging to the United Smelting and Refining Co.), the writer had occasion to make a series of studies in mechanical feeding which elucidated a number of

underlying principles in an interesting way. These studies also resulted in the evolution of an eminently satisfactory feeding-device. The successive steps in its development are sufficiently instructive to warrant a detailed and critical description.

Mr. H. W. Hixon, then superintendent of the plant, had designed and installed the original form of the mechanical feeding-device; and the subsequent modifications, which I will describe, were made with the co-operation and concurrence of Mr. Hixon, whose practical skill and experience contributed very largely to the final success.

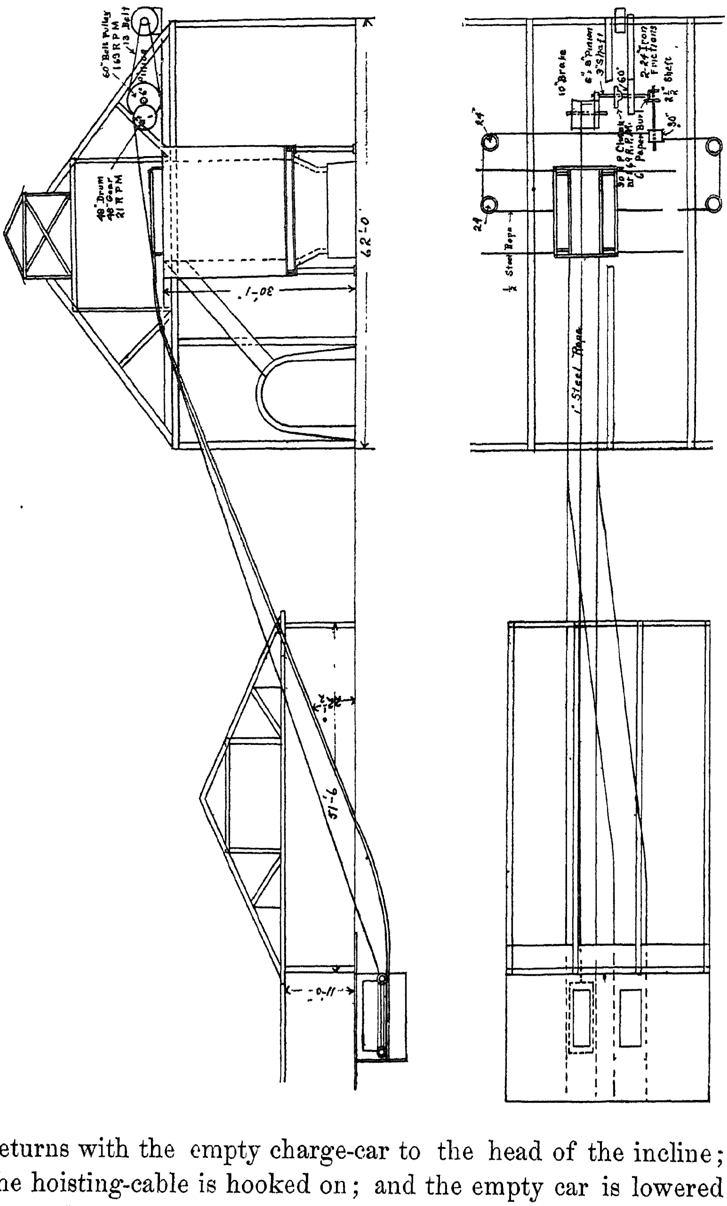
(a) *The Hixon Mechanical Feed (Original Form).*—The furnace-plant at East Helena consisted (as late as 1900) of four lead-furnaces, each 48 by 136 in., with a 21-ft. smelting-column, and a small copper-furnace, which, however, was not arranged to feed mechanically. They were all open-top furnaces, fed through a slot over the center, the gases being taken off below the floor. The charges for hand-feeding were elevated from the furnace-floor level by two platform-elevators. The furnaces were capable of smelting about 180 tons of charge (ore and flux) per 24 hours, using a blast of 30 to 48 oz. pressure, furnished by two E. P. Allis duplex horizontal piston-blowers, air-cylinders 36-in. diameter by 42-in. stroke, belted from electric (induction) motors.

The Hixon mechanical feed was designed to meet existing conditions, and to supplant hand-feeding, without irrevocably cutting off the possibility of conveniently returning thereto in an emergency. It had some mechanical faults, to be discussed later, which would undoubtedly have been avoided if an entire new plant had been designed instead of the modification of an old plant.

The details, shown in Fig. 13, include a track-way at right angles to the battery of furnaces, leading from a point near the bins to a transfer-carriage standing on the charge-floor between two of the lead-furnaces. The car is hoisted up the incline endwise by a direct-hoisting cable, the winding-drum of which is situated on the upper level, and actuated by a friction-gear connection with a line-shaft. The transfer-carriage, upon which the charge-car stops at the crest of the incline, can, after detaching the hoisting-cable, be moved over the tops of

the furnaces by means of a tail-rope system. The gauge of the charge-car is 4 ft. 9 in.; that of the transfer-carriage, 11 ft. 8 in. After discharging into the proper furnace, the transfer-carriage

FIG. 13.

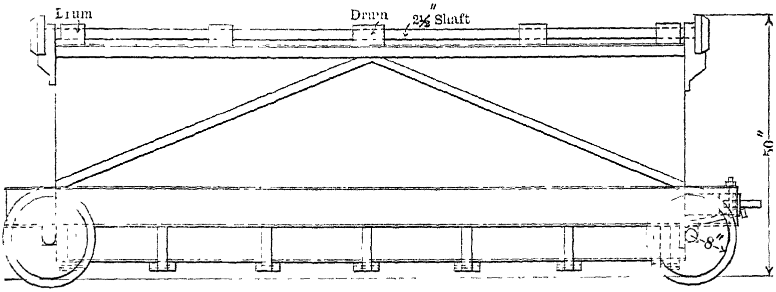


East Helena System: Vertical Longitudinal Section and Plan of Incline.

returns with the empty charge-car to the head of the incline; the hoisting-cable is hooked on; and the empty car is lowered down the incline to the charging-pit below the level of the bin-

floor. It should be noted that a hand-winch is necessary to start the car from the transfer-carriage and down the incline. A switch at the lower end of the incline permits two charge-cars to be employed, one being filled while the other is making

FIG. 14.

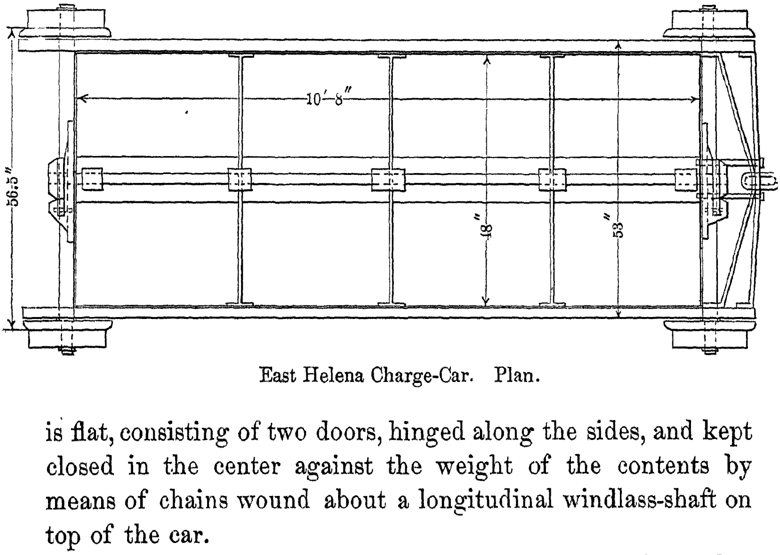


East Helena Charge-Car. Side Elevation.

the trip. Figs. 14, 15, 16 and 17 show details of the charge-cars and transfer-carriage.

The charge-car is 10 ft. long by 4 ft. wide by 3 ft. 6 in. high, and holds a total charge of 6 tons of ore, flux, slag and fuel, the total of ore and flux being usually 8800 lbs. The bottom

FIG. 15.



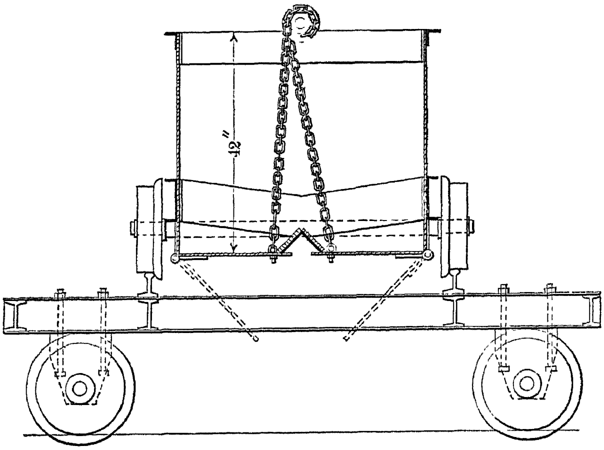
East Helena Charge-Car. Plan.

is flat, consisting of two doors, hinged along the sides, and kept closed in the center against the weight of the contents by means of chains wound about a longitudinal windlass-shaft on top of the car.

The charging-pits are decked with iron plates, leaving a slot,

along the center of each car, exactly like the feeding-slot in the furnace-top. As the wheelers bring the ore-buggies containing weighed-up ingredients for the charge, the buggies are taken by two attendants especially responsible for this duty, who carefully distribute the contents of each buggy along the whole length of the charge-car by dragging it along the slot while in the act of dumping. Each buggy contains but one ingredient, and they follow one another in a prescribed order, so as to secure thin layers in the charge-car. The coke, instead of being placed on top of the other ingredients, as at Pueblo, is divided into three or more layers.

FIG. 16.

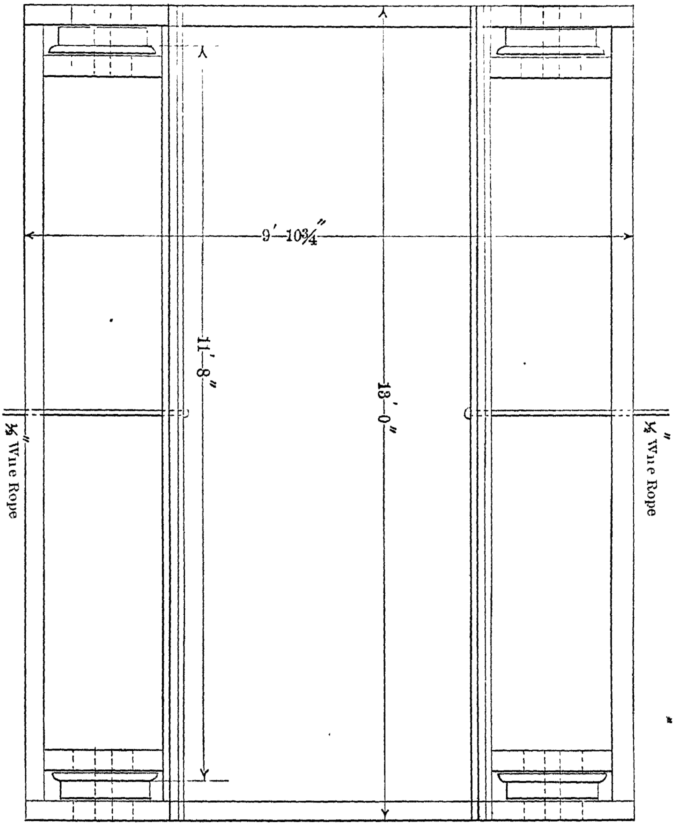


East Helena Charge-Car and Transfer-Carriage. Elevation.

The first few trials of this feeding-device were not satisfactory. The furnaces quickly showed over-fire and decreased lead-output, which would not yield to any remedy except a return to hand-feeding. When the writer visited the plant in April, 1899, the furnaces were being fed by hand, the mechanical feeding-device having lain idle for some weeks. On request, it was started up; and, as before, the furnaces began within a few hours to show signs of over-fire. A consideration of the principles already stated will clearly indicate why. The total charge being dropped in the center of the furnaces, a central core of fines was produced; the lumps tending to roll and arrange themselves along the walls. We thus had

exactly the reverse of the proper disposition of coarse and fine in the furnace. (See Fig. 18.) A study of the minutiæ of the actual operation showed that this wrong tendency was emphasized by the presence of the chains supporting the bottom-doors of the charge-car. On unwinding the windlass-shaft and releasing the chains to dump the car, the bottom-doors were

FIG. 17.



East Helena Transfer-Carriage. Plan.

prevented from dropping by the wedging of the chains in the charge, which, in turn, arched itself more or less against the sides of the car; hence the doors opened but slowly, and often had to be assisted by an attendant with a bar. In consequence of this slow opening and the jamming of the coarser part of the charge around the chains, considerable fine ore sifted out first,

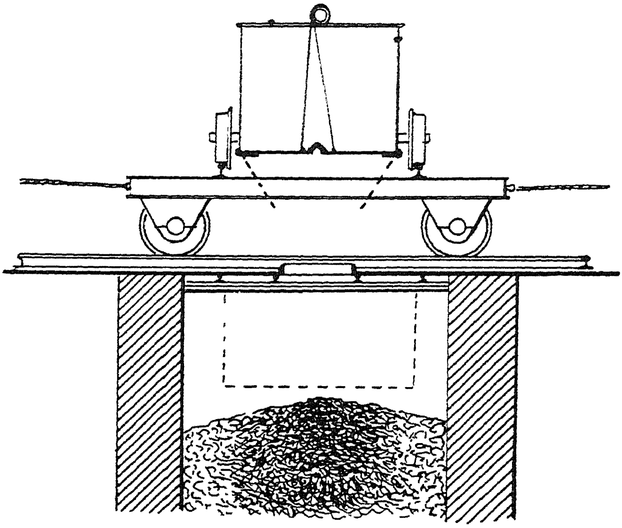
and, dropping into the center of the furnace, formed a ridge, from the slopes of which the coarser part of the charge, the last to fall, naturally rolled off toward the side-walls of the furnace. This fact, once determined, proved to be the key to correcting the evil; and the classification of material effected by the gradual opening of the car-bottom was taken advantage of to produce a reversal of the former distribution in the furnace. The attendant operating the tail-rope mechanism was instructed to move the transfer-carriage rapidly backward and forward over the slot while the first one-third or one-half of the charge was dropping, and, during the rest of the discharge, to let the car stand directly over the slot and permit the coarser portion to fall in the center of the furnace. Two piles of comparatively fine material were thus left on the charge-floor, one on each side of the slot. These were subsequently fed by hand, with instructions to throw the material well to the sides of the furnace.

The furnaces were running very hot on top when this modified procedure was begun. In a few hours, the over-fire had disappeared; the lead-output was increasing; and the furnaces were running normally. This result was accomplished about May 1, 1899. From that time until about February 20, 1900, the Hixon mechanical feeding-device was continuously operating under this modified procedure. The behavior of the furnaces and the metal-results during that period were about the same as they had formerly been with hand-feeding.

At first glance, considering the few men required on the charge-floor, there appeared to be a considerable saving in labor by the use of the mechanical feed; but in reality this was offset by increased labor required downstairs—extra wheelers, charge-car feeders, and the higher wages paid to the few men in attendance on the machinery. In order to get a fair comparison, the following figures were taken:

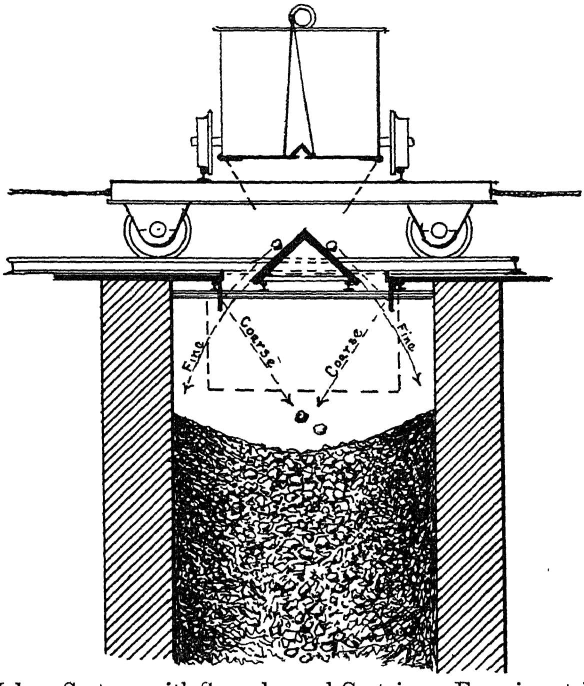
In October, 1898, three furnaces were in operation with hand-feeding. The pay-roll for that month showed an average labor-cost on the blast-furnace of $42.06 per furnace-day. In October, 1899, the same number of furnaces were in operation with the Hixon feed under the modified procedure, and the average labor-cost for the month was $41.00 per furnace-day, a saving over hand-feeding of only $1.60 per furnace-day, or $\frac{6}{10}$c. per

FIG. 18.



East Helena System: Original Scheme.

FIG. 19.



East Helena System, with Spreader and Curtains. Experimental Form.

ton of charge. These figures will be commented upon later in comparing with the work at Pueblo.

(b) *The Dwight Spreader and Curtains, Modifying the Hixon Feed.*—In January, 1900, the writer had occasion to visit the East Helena plant again, to investigate an interesting problem involving the peculiar behavior of certain cokes. A cheap local coke, logically and commercially the fuel that ought to be used at this plant, had invariably caused bad work in the furnaces; and the only coke that seemed to give good results was Pennsylvania or West Virginia coke, which cost at that time, delivered at the works, about $4.25 per ton more than the local coke. This difference in the cost of coke amounted to about $130 per furnace-day, or nearly $12,000 per month, in the operating cost. A line of investigation was undertaken which developed some most interesting facts, and finally was entirely successful in demonstrating the cause of the difficulty with the coke. A new practice was established which entirely corrected the difficulty, and made it possible to use the local coke with eminent success. A full account of this investigation of the fuel-problem and the results obtained would not be strictly in place in this paper. Suffice it to say, the peculiar behavior of the cokes was traced, strange as it may seem, to improper feeding of the furnaces.

The "modified procedure" with the Hixon feed, which had been in operation for nine months with apparent success, was found, after a thorough study, to be far from perfect. On account of certain peculiarities of construction in the furnace-top, particularly the narrow feeding-slot in the top-plates, it was very difficult for the workmen to throw the fine stuff with their shovels as far to the sides as the furnace-walls, according to instructions. This fact, clearly established by repeated tests, has been already mentioned above.

It became necessary, then, to design some kind of mechanical spreader which should properly distribute the material as discharged from the Hixon charge-car, and at the same time to dispense entirely with the partial hand-feeding which had been necessary with the "modified procedure." We tried a temporary wooden construction and obtained eminently successful results, developing a complete solution of the feeding-difficulty, and also of the trouble with the cokes. After getting the feeder

correctly adjusted, it was found possible to obtain better metallurgical results with the cheap local coke than had formerly been obtained with the much more expensive Eastern cokes.

Figure 19 shows the principle of the scheme adopted. In the temporary construction used for purposes of experiment, the flanged cast-iron plates around the feeding-slot were pushed back some distance, and a roof-shaped spreader, with slopes of 45°, was set in the gap, leaving two openings, each about 8 in. wide, on either side of the spreader. The doors of the charge-cars, when hanging down, would just clear the ridge of the spreader. In order to test thoroughly the working of this device before a permanent installation was made, the spreader was built of wood, with the faces sheathed in sheet-iron. The original plan provided for two iron curtains to be hung, one on each side of the spreader, and so adjusted, with respect to the trajectory of the ore-stream from its slopes, that the fine material would just clear the edge of the curtain and continue without interference until it lodged close to the furnace-walls. The pieces of large diameter would not clear the edge of the curtain, and the angle at which they rebounded would carry them toward the center of the furnace. The object of the curtains was twofold: (1) to classify the coarse and fine, as just explained; and (2) to protect the side-walls of the furnace from abrasion by the lumps of ore.

The same results might have been accomplished by hanging, in the path of the falling material, iron gratings which would permit the fine to pass, while the coarse would be intercepted. But the curtain was thought better, because a very fine adjustment was possible by simply raising and lowering the curtain a few inches, so that any degree of classification could be obtained. The lower the curtain was placed, the smaller the diameter of the particles that could pass unmolested, until a point would finally be reached when the whole stream would be interrupted and diverted from the sides; this, of course, being the extreme limit. If desired, the curtain could be adjusted at such a height that the medium-sized particles could lodge with the fine along the walls. When the conditions of the charge made it desirable to feed the coarse and fine together against the walls, this could be quickly provided for by raising the curtains still higher. Thus, by experiment, it would

be possible to find the adjustment best suited to the conditions of the furnace and the particular nature of the charge.

In the temporary construction first installed, the curtains were provided for by simply bending down the thin sheet-iron floor underlying the cast-iron plates of the furnace-top. Crude as they were, these curtains did their work of classifying surprisingly well. No. 5 furnace was first to be changed in the manner described; and an immediate improvement in its work was shown. It averaged better in speed, with lower blast, lower lead in slag and matte, and better bullion output than the other furnaces operating under the old system. In fact, the results were so satisfactory that spreaders and aprons of similar temporary construction were promptly placed on all the other furnaces, and remained in service until, in the course of time, they were replaced by more permanent constructions of iron, modelled along the same general lines. It is sufficient proof of the good behavior of the furnaces, while being fed in this way, that during the several weeks that these wooden spreaders were in place over the furnaces, and in direct contact with the furnace-gases, they were not once in danger of taking fire.

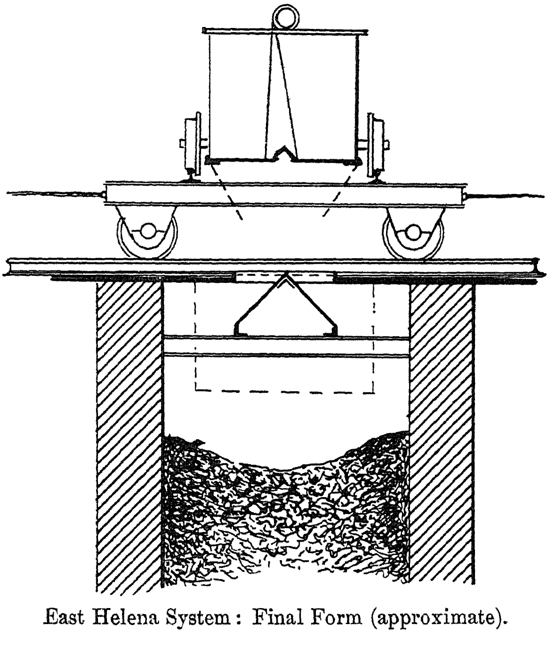
The temporary curtains, being made of thin sheet-iron, naturally wore out very quickly, and thereafter the whole charge, both coarse and fine, fell from the spreader against the walls. This style of feeding also gave good results, as the fine tended to remain close to the walls during the descent of the charge, while the coarse tended to roll and to work its way towards the center of the shaft. During the gradual wearing-away of the curtains, it was possible to observe the behavior of the furnaces under the different adjustments of curtain-length. The writer is convinced, from his observations at that time, that the curtain is a valuable adjunct to the spreader as a feeding-device.

At this juncture, the writer was called away from East Helena by other business; but the general scheme, as established by the preliminary studies and experiments, was carried out. The temporary wooden spreaders were soon replaced with spreaders of iron, the only difference being that they were lowered so as to bring the ridge of the spreader level with the floor, somewhat as shown in Fig. 20, though it must be

admitted that this sketch is based upon possibly imperfect information. I understand that no curtains were used in the permanent construction, since the feeding seemed to be satisfactory without their aid. In their absence, the lowering of the spreader was a proper step, as it distributed the material fully as well, and caused less abrasion of the walls. Moreover, it permitted a smaller opening in the furnace-top, which, on account of deficient draught, was an important consideration.

The Hixon feed, as thus modified by the writer, seems to

FIG. 20.



East Helena System: Final Form (approximate).

have given complete satisfaction at East Helena since February, 1900. Moreover, the spreader has been adopted as the basis for the mechanical feeding-device in the new plant of the American Smelting and Refining Co., just completed in Salt Lake City, Utah.

The writer is not aware of any previous application, at least in lead-smelting practice, of the principle of the fixed spreader. At the same time, no special claim of originality is made for it, since it is no more than the development, for a rectangular furnace, of the general idea of the cup-and-cone

feed of a round furnace, adapted to meet particular necessities. It is to be considered as a design rather than a new invention.

XIV. Comparison of Systems.

The cup-and-cone feeder, however suitable for round furnaces, can be briefly dismissed as inapplicable to the rectangular lead-furnace. Of systems which have been in continuous operation for considerable periods, and can thus afford positive data for intelligent comparison, there remain, therefore, only two which I can discuss, namely, the Pueblo and the East Helena system.

Mechanical Design.—The Pueblo system is better, because simpler in construction and operation. No time is lost in attaching and changing cables, operating transfer-carriage, etc. In comparing the two we should remember, however, that the Pueblo plant was remodeled throughout with the special object of mechanical feeding in view, while at East Helena a system had to be devised to fit a plant already built. Both systems have the main track for the charge-car running directly over the tops of the furnaces, and this is a positive inconvenience when any furnace-repairs are under way.

Charge-Car.—The Pueblo car is simpler, because it can be dumped instantly, having no chains or other attachments to jam in the charge and prevent the doors from opening promptly. East Helena has two cars in service, while Pueblo has but one; but inasmuch as the latter, owing to fewer delays, makes a round trip in about one-half the time of the former, there is not much difference on this score.

Filling Charge-Car.—The Pueblo system is quicker, in that two buggies are dumped simultaneously, one into each end of the car, while at East Helena each buggy is handled singly, and the contents are carefully distributed along the length of the car. We may roughly estimate, therefore, that, per ton of capacity, it takes $2\frac{1}{2}$ to 3 times as long to fill the East Helena car; and this means longer waiting on the part of the wheelers, and consequently greater cost of moving the material, representing probably about 7 or 8 cents, in favor of Pueblo, per ton of charge handled. However, both methods of filling the car are wasteful of labor, because they require the wheelers to time their movements by the movements of the charge-car.

It is true that these men require some period of rest, and it may be urged that they might as well rest while waiting for the charge-car as any other time; but it is a practical fact that the actual labor of moving the material can be apportioned with far greater economy if this work can be made independent of all other considerations, and if the men can shape their work strictly in accordance with the requirements of that work only. Of course, the necessities of the furnace are imperative, and there must be no delay in sending up a charge when it is needed; therefore enough men must be on hand during the whole shift to meet the necessities that may arise in any ordinary emergency; and this means the carrying of more men than could efficiently and easily move the required tonnage of material.

Furnace-Results.—It has been shown that the arrangement of coarse and fine material in the East Helena car is adapted to give a uniform longitudinal arrangement in the furnace parallel to the furnace-walls, while in the Pueblo car we have two cores of fine material, the correct subsequent rearrangement of which is necessarily difficult. The "cross-distributors" in the Pueblo furnace probably accomplish this as well as can be expected; but at the very best they must be regarded as a compromise. Manifestly, it is better practice so to plan the operations that the governing principle and ultimate requirements shall be kept constantly in view from the start. It is believed that the better distribution in the East Helena car results in greatly increased regularity of furnace-running, less tendency to over-fire, some economy in fuel, less accretions formed on the furnace-walls, and larger metal-savings. If the half of these conclusions are true, then the saving of 7 or 8 cents a ton at Pueblo, which can be traced almost entirely to the cost of filling the charge-car, sinks into insignificance in comparison with the important advantage of having the furnaces uniformly and correctly fed.

XV. The True Function of the Charge-Car.

It will assist us in the study of problems of this kind to define the radically essential feature of a mechanical feeding-device as that part which automatically distributes the material in the furnace, whatever appropriate means may have been used to effect the delivery.

Taking a hasty review of the numerous feeding-devices that have been tried in lead-smelting practice, we cannot but remark the fact that those which depended upon dumping the charge into the furnace from small buggies or barrows failed generally to secure a proper classification and distribution of coarse and fine, and, consequently, were abandoned as unsuccessful, while the adoption of the idea of the charge-car for transporting the material to the furnace in large units seems to have been coincident with a successful outcome. It is natural enough, therefore, that the car should be regarded by many as the vital feature. This view of the question is not, however, in accordance with the true perspective of the facts, and merely limits the field of application in an entirely unnecessary way. It must be apparent that the essential function of the charge-car is cheap and convenient transportation. The distribution of the charge is an entirely different matter, in which, however, the charge-car may be made to assist, as in the Pueblo system; or entirely distinct and special means may be employed for the distribution, as in the East Helena system.

To follow the argument to its conclusion, let us imagine for the moment that the East Helena plant were arranged on the terrace-system, with the furnace-tops on a level with the floor of the ore-bins. Certain precautions being observed, the "spreader" would give as good results with small units of charge delivered by buggies as it now does with the larger units delivered by the charge-car, and the expense of delivery to the furnaces would be practically no more than it now is to the charge-car pit. The furnace-top would, of course, have to be arranged so that the buggies, in discharging, could be drawn along the slot, so as to give the necessary longitudinal distribution parallel to the furnace-walls, just as is now done in filling the charge-car. The ends of the "spreader," if built like a hipped roof, would secure proper feeding of the front and back.

Thus, by eliminating the charge-car, and with it the necessity for powerful hoisting-machinery, with its expensive repairs and operating-costs, we may greatly simplify the problem of mechanical feeding, and open the way for the adoption of successful automatic feeding in many existing plants where it is now considered impracticable.

XVI. General Conclusions.

In this brief review of the subject, the following points should be brought out in strong relief:

1. Upon the mechanical character of the furnace-charges, and the manner in which the coarse and fine are disposed in the smelting-column, depend to a great extent the best results in lead-smelting. The efficient utilization of fuel and blast, the close adjustment of slag-composition, and the most perfect maintenance of uniform smelting-conditions must be preceded by the effective regulation of this factor.

2. Since variations in the feeding are not susceptible of precise measurement, as are the other factors in the blast-furnace process, our only safe means of regulation is to reduce the feeding to a constant. This must be done by establishing a system of feeding from which the uncertain human element is eliminated as much as possible—in other words, a system of mechanical or automatic feeding intelligently designed to meet local conditions.

3. In designing such a system, the first point to be decided is the most economical means of transporting the charges to the furnaces, whether in large or small units, by car, barrow or buggy. This once determined, a little study and ingenuity should evolve the simplest means for invariably effecting such a distribution of the charge so delivered as will comply with the requirements of good feeding.

4. Assuming that suitable preliminary preparation has been given to the material, we may briefly summarize these requirements under two specifications:

Transversely, a classification and disposition of coarse and fine material, such that the resistance to the ascending gases shall be equal at all points of the section;

Longitudinally, a perfectly even arrangement of these classes parallel to the furnace-walls.

Notes on Certain Mines in the States of Chihuahua, Sinaloa and Sonora, Mexico.

BY WALTER HARVEY WEED, WASHINGTON, D. C.

(Mexican Meeting, November, 1901.)

THE notes given in this paper, the result of observations made during recent brief professional trips to the northern States of Mexico, are offered as a slight contribution to the geological knowledge of a region little known, but long famous for its rich gold- and silver-mines. They are not detailed geological studies, but they contain, I believe, the salient facts.

The following districts were visited: 1. Santa Eulalia (silver-lead); 2. Parral (silver-lead); 3. Las Vigas (copper); 4. Jimenez (copper); 5. Guadalupe y Calvo (gold); 6. La Cumbre (gold); 7. Palmarito (silver); 8. Cananea (copper); 9. Sierra Pinitos (gold); 10. Sierra Azul (gold).

1. THE SANTA EULALIA SILVER-LEAD DEPOSITS.

Seventeen miles SE. of Chihuahua is the mining district of Santa Eulalia, to which that city owes its origin and long prosperity. Discovered in 1703, this district has been, and still is, one of the great silver-lead producers of the world. For 86 years after its discovery, the total output upon which the crown tax was paid amounted to $112,000,000. Worked until within the last 20 years by the most primitive methods, without machinery of any kind, the deposits continued to yield a vast treasure of silver; at present the yearly tonnage far exceeds that of former times.

A broad-gauge road runs from Chihuahua up the valley of a small creek to the village of Santa Eulalia, which is situated within the borders of the mountains of that name. A few miles out of Chihuahua a narrow-gauge railway, owned by the Chihuahua Mining Co., branches off to the mines. This road ascends a smooth but steeply-rising plain to the base of the mountains, and winds about the slopes until the mines are

reached. The same company owns extensive reduction-works 3 miles from Chihuahua; but in 1900 the ore from all the mines was shipped to the custom smelters.

The principal mines have been operated for the past decade by Americans, and are fully equipped with modern hoists and engines, and all the accessories of a first-class plant.

The Santa Eulalia district embraces about 5 sq. miles of rugged, mountainous, but not very high, country, forming part of a NE.–SW. range, separating the Conchos and Toyoba valleys.

Geology.

The *Mesa Central*, near Chihuahua, consists of folded limestones covered and largely concealed by dacitic rocks, mostly cemented volcanic ejectments covering granitic intrusions. The hills rising above the plain are mainly of the dacitic tuffs. The Santa Eulalia range is said by J. P. Kimball, who described the district in 1870, to be composed of folded Cretaceous limestones, the ore-deposits being in a local dome-shaped uplift, now deeply trenched by numerous narrow gorges radial to the slopes. The age of these rocks, determined by Kimball from the fossils he collected, is confirmed by similar evidence gathered by myself. The limestones are massively bedded, and form steep slopes and abrupt cliffs comparable to those of the Carboniferous "Mountain limestones" of the Rocky Mountain region. The deeply eroded and hilly surface of these rocks is overlain by a mantle of dacitic tuff, filling the old gorges and hollows, and completely obliterating the old topography except where it has been bared by later erosion. This dacitic rock, called *Cantera** by Kimball, from its local name as a building stone in Chihuahua, is clearly shown by its field-relations, and by the microscopic study of thin sections, to be a volcanic breccia. It is mentioned in a paper on the Sierra Mojada mines, SE. of Santa Eulalia, by Mr. Malcolmson, who notes the similarity of the formations at both places. According to him, the breccia is 1800 ft. thick at the latter place (present volume, p. 107).

The presence of feldspar crystals and limestone fragments is very common in breccias formed of the rock-fragments and ash-showers ejected by volcanoes, and either swept down by

* *Am. Jour. Sci.*, 2d series, vol. xlviii. (1869), p. 379.

rains or moving as mud flows down the slopes and filling the hollows. Where the volcanic vent has broken up through limestone, the fragments of limestone torn off by the outbreak (and rounded, perhaps, by frequent falling back into the crater and consequent attrition) are finally ejected, mixed with lava fragments, by more violent outbursts. Such feldspar fragments and crystals are usual constituents of most volcanic breccias.

Character of the Ores.

The ores consist mainly of lead carbonate (cerussite) with nucleal masses of galena. Rich bonanzas of chloride and sulphides of silver, and (more rarely) of embolite and iodyrite, have been found. All the ore-deposits occur in the limestone, and are similar, in many respects, to those of the Sierra Mojada; but hitherto, so far as I have been able to learn, no valuable contact-deposits have been discovered. At the Santo Domingo mine, Kimball has described* a vertical fissure or feeder, and the outcrops of other but barren fissures may be seen nearby. This Santo Domingo fissure appears to have been the feeder or pipe for the solutions making the greater ore-bodies which are found along the bedding-planes of the limestone, and are, to a lesser degree, controlled by the jointing of the rocks. The main ore-bodies consist of loosely-textured cerussite, resulting from the alteration of galena, of which residual masses are frequent.

Santo Domingo.

This is the most famous mine of the district. The ore-body is an almost ideal example of the metamorphic replacement of limestone. The limestone rocks are well-bedded, and contain occasional fossils, several inches across,† with chert-balls and concretions, commonly arranged along planes nearly parallel to the bedding. The ore shows the fossils and chert-bands in their original and undisturbed position, corresponding closely to those of the unreplaced parts of the limestone having the same structure that are seen in the walls. The upper and lower limits of the deposit are unusually regular for deposits of this

* *Am. Jour. Sci.*, 2d Ser., vol. xlix. (1870), p. 165.

† Especially *Ostrea carinata* Lam., which is characteristic of the Washita division of the Comanche Group of the Lower Cretaceous.

kind, and in places are plainly seen to be determined by stratification-planes. Such planes were observed to be the surfaces of layers of more earthy or less easily replaceable lime-rock. The side-boundaries of the deposit present in places all the pitted and "pot-hole" structure which I have frequently observed to be characteristic of such replacement deposits. While there is sometimes a very abrupt change from ore to limestone, with no intermediate products, there is often a thin shell of iron oxide and silica; and stringers of such material lead from one ore-body to another. The ore is also abruptly limited at times by joint-planes. Boulders of unreplaced limestone occur in the ore; but as a whole the limestone is not shattered, and, where it is broken, this is the result of movement since the vein has been worked. Open caves occur, but, in the cases observed, are due to the later circulation of waters that changed the ore from galena to cerussite. A slight secondary enrichment by these waters produced the rich sulphides, chlorides and iodides of silver found on the walls of the caves. The old workings were sparingly timbered; and spaces large enough to hold the Chihuahua cathedral are mentioned by Kimball. By reason of a disastrous cave, which took place a few years ago, these old workings are now inaccessible.

2. The Parral Mines.

Santa Barbara.

The old camp of Santa Barbara, 8 miles from Parral, is reached by a branch of the Mexican Central railroad. In November, 1900, this line had been completed, but no trains were yet running, and the town was reached by a drive over the low, rolling hills near Parral, and across an open, black valley-bottom to the mouth of the gulch in which the town is situated. Santa Barbara offered a fine example of a mineral district just being extensively opened by strong corporations. The old town, at one time the capital of the State, lies close under the mountains and just within the foothills, which separate it from the beautiful broad meadows of the Santiago ranch. The mines were as yet undeveloped; the only previous work having been the "gophering," characteristic of all Mexican properties, which had resulted in irregular openings seldom more than 50 to 75

ft. deep, extended by cuts or drifts to strike richer portions of the veins. The expenditure of much money in developing the mines for a regular production, and in erecting reduction-mills, warrants the expectation of a large output hereafter. There is a striking contrast between the squalid *adobe* buildings of the town and the modern machinery and newly-laid railroad-tracks of the new enterprises. Several old Mexican *adobe* furnaces still exist; and in the center of the valley a slag-dump, said to carry over 40 oz. of silver per ton, forms a valuable asset of one of the mining companies.

The rocks in which the veins occur are indurated gray shales, the ready splitting of which along bedding-lines has caused them to be called slates. They carry little, if any, interbedded quartzite, and no limestone was observed. The rocks are folded, but in general dip W., towards the mountains.

The veins show rough brownish outcrops, forming walls rising several feet above the general surface, but seldom continuous for any considerable distance. The veins are clearly true fissures with irregular rolling walls and contain much crushed shale. The vein-quartz, cementing the fragments and forming breccia, shows marked banding and crustification. Fluorite and stilbite were observed at the Primrose property, at the lower end of the valley, but were not seen in the big veins of the Moctezuma Co. Near the town, dikes of rhyolite cut the shales. A large one was observed on the crest of the ridge north of the town; another comes down the lower ridge which encloses the valley, and appears on the southern slopes, where its high and brown outcrop resembles those of the two veins seen east of it. The largest dike appears back of the *Arroya de Vaca*, where it is crossed by another dike showing as a big reef near the Alfreina mine. The fact that the ledge, varying from 15 to 20 ft. in width, of the *Mina de Agua* is called "small" by the superintendent of the Moctezuma company, indicates the great size of the veins cutting the slopes at the head of the *Arroya de Vaca*. These veins are said to be from 50 to 100 ft. in width. The veins are all traceable for long distances, certainly for a mile or more, and the *Mina de Agua* vein shows a large outcrop 15 or 20 ft. high (a so-called blow-out of quartz), which is most prominent where two veins cross one another. The ores consist of galena,

with a little pyrite, and some zinc in a quartz gangue. In general the veins follow a north and south direction, crossing parallel to the porphyry dike already mentioned. This dike is certainly faulted at the *Canada Vaca*, and another fault was observed near the railroad track. Whether these faults throw the veins as well as the porphyry dikes could not be ascertained. To one fresh from the mines of Montana, the ores appear to be base and the values rather low; but the zinc is largely eliminated in milling, and by reason of the cheap labor of Mexico and the favorable conditions existing at the smelters, the properties yield great profits.

The Guggenheim Co. owns a 60-ton mill, just below the old town of Santa Barbara, on the *Capia* ledge, supposedly the same as the *Alfreina.* The ores from the *Palo Blanco* and the *Tecolotes* mines are treated in this mill, the product of the latter property being transported more than ¾ m. by a tramway. This is the mine for which $700,000 is reported to have been paid when the vein was practically undeveloped, save by open-cut and "gopher" holes of the Mexicans.

The Kansas City Smelting & Refining Co., operating as the Moctezuma Mining & Milling Co., owns two important parallel ledges outcropping at the base of the slopes north of the valley, a little below the town. These veins were recently purchased for $110,000, and the rapid development of the district is shown by the fact that for years the property had been offered for sale and found no bidders at $10,000 Mexican money. In November, 1900, when I visited the property, the ground was being graded for a new 250-ton mill and an extensive mining-plant. The ore of these veins consists of galena with pyrite and zinc-blende in quartz. The average composition is: Lead, 7.5; zinc, 6.5; copper, 0.27; iron, 5.0; lime, 8.0, and silica, 50.0 per cent.; silver, 6 oz., and gold, $1.40 per ton.

The ore occurs in defined pay-streaks and shoots in white quartz. The quartz shows a banding due to a linear arrangement of grains of the metallic sulphides, and sometimes (though rarely) a crustification, with quartz-lined vug-lines, or drusy cavities lined with calcite. The vein is encased in dark-gray slates, supposed to be Cretaceous, which dip SW. 20° to 30°, and fragments of which occur in the vein-filling. The vein appears to have been formed by the filling of open fissures;

the dull amorphous-looking conchoidal-fracturing quartz of replacement-deposits not being abundant nor conspicuous. The vein is about 20 ft. wide, averaging, it is said, 10 ft. of ore. It dips at first 85° W.; changes to nearly vertical between 100 and 200 ft. in depth, and to an east dip below that.

3. The Las Vigas Copper-Mines.

These mines are about $1\frac{1}{2}$ m. N. of the Conchos river and 70 m. NE. of Chihuahua, the nearest town being Coyame, a village some 40 m. from Presidio del Norte. The mines are at present remote from a railroad, though the survey-line of the Chihuahua & Pacific passes near them.

The country between the Rio Grande and Chihuahua, a part of the *Mesa Central*, shows numerous narrow isolated mountain ranges with intervening pocket-valleys or wide expanses of undulating plain. The flora reflects the aridity of the climate; *yucca*, *sotól*, *mesquite* and other arid-land plants being the only vegetation. The ranges consist of folded limestones, usually in defined anticlinal folds. These rocks occasionally show also in the plains, but are more commonly concealed by soil or *débris*. Occasionally the mountains are capped or flanked by masses of dacitic porphyry, rarely massive, commonly tufaceous, and showing a rude bedding such as characterizes the deposits of fragmental ejectamenta from volcanoes. So far as known from the evidence of the fossils actually seen, the limestones are Cretaceous and the tuffs of later age.

The copper-veins occur in the SW. foot-slopes of a mountain ridge composed of steeply dipping, massively bedded limestones. The veins are impregnated sandstone strata, forming part of a continuous series of Cretaceous rocks, several thousand feet thick. The beds are on edge (Fig. 1), dipping very steeply, and are well exposed, so that a good section could be easily obtained. Between the base of the limestone mountain range on the east and the ore-bearing strata there is a belt of shale carrying fossils. Specimens from this bed were determined by Mr. R. T. Hill to be of Comanche, *i.e.*, Lower Cretaceous age. The sandstones above this shale belt are pure quartzose rocks that alternate with soft argillaceous shales and rarely with limestone; but a mile to the north the sandstones are replaced by limestones, the beds of each rock showing in their imbrication-

and transition-forms that when they were formed the sea lay to the north.

Three definite ore-seams occur (Fig. 2). Though called veins, they are really beds of sandstone and shale from 4 to 7 ft. wide and coursing N.–S., impregnated with copper carbonates, oxides and sulphides. In addition to the three main ore-carriers, there are several cross-fractures and veins which fault the beds and carry little bunches of copper-ore in calcite gangue. The "vein-walls" are sharply defined by shale; but bands of shale included in the vein are mineralized. There is little true gangue mineral, so far as observed; the silica being merely that of the original sandstone.

A mixture of 18 samples of ore and gangue from a large number of cuts across the vein gave: Silica, 74.4; iron, 8.5; lime, 2.0; copper, 5.2 per cent.: gold, 0.6, and silver, 1.45 oz. per ton.

The outcrops of the veins usually show some green staining or malachite in a laminated sandstone reef. The surface-ores consist mainly of malachite, but at a depth of 35 to 50 ft. "glance-ore" is encountered—a black sandstone in which the quartz grains are coated and cemented by rather earthy-looking copper sulphide. It is impossible to say whether any replacement of the quartz has taken place; but the ore carries from 20 to 30 per cent. of copper. That it will pass into chalcopyrite in depth is indicated by occasional specks of that mineral in it.

Origin of Veins.—These ore-bearing strata are impregnated because the rocks were extremely porous. Hot springs existed nearby and formed deposits of tufa; and there may be some genetic connection between this and the copper-seams, though it appears to me more probable that the springs are of very recent origin. The fault-veins of gypsum, calcite and copper that cross the main ore-beds are clearly of later age. They cannot be, as was at first believed, the feeders for the main veins, carrying the mineral-bearing solutions out into the porous beds crossed by the fault, for the gangue of the two sets of veins is essentially different; moreover, the ore-veins are, if anything, poorer near these cross-fractures, and maintain high values far from them which would negative the hypothesis mentioned. These faults throw the strata from 8 to 30 ft. to the west, *i.e.*, on the north side of the fault.

The main veins (Figs. 3, 4 and 5) consist of sheeted or fractured sandstone, with malachite, azurite, and more rarely cuprite films, along the fractures. The ore fades into the sandstone. The shale belts between the sandstone layers of the vein carry much ore in films and nodules. Though there is little apparent brecciation of the rocks, and no slickensides or clay selvages, it is evident from the occurrence of the ore along the fractures of the vein-fissures that there has been some movement and shattering of the rocks. Commonly the veins show a plating or sheeting of the sandstone. Below the influence of surface-waters, at a depth of 42 ft., the vein carries glance. It is here crossed by flat fractures—mere films, partly of gypsum and partly of calcspar, which occur 5 to 7 ft. apart vertically and delimit the ore; that is, they show that the glance is the result of descending waters. The interruption caused by such films is only temporary; for rich ores occur below, but the sandrock immediately below each fracture is relatively lean. The vein (Figs. 3 and 6) is sheeted by vertical fractures into slabs ½ in. to 4 in., but mostly less than 1 in. thick, and the gypsum films of fracture-planes are from ¼ to ½ in. thick.

4. The Jimenez Copper-Deposits.

These deposits occur a few miles SW. of Jimenez, where the Parral branch of the Mexican Central railway leaves the main line. The region is part of the *Mesa Central*, which here has an altitude of 4500 ft. The general surface (Fig. 7) is diversified by isolated hills and low mountains, many of which show bedded dark gray limestones. The group of hills in which the copper-deposits occur consist of limestones and shales cut by igneous intrusions. The northern ridges are largely formed of massive rhyolite porphyry; but further south the hills terminate in a nearly circular ridge of eroded limestones and shales, which seem to dip away on all sides from a central mass of coarse-grained granite eroded into a basin or amphitheater.

The copper-ores occur in a typical contact-deposit of the Kristiania type. As indicated in the accompanying diagram, Fig. 8, the limestones once arched over and covered the granite. The deposit follows the line of contact between limestone and granite, and the contact phenomena vary somewhat. Most frequently the limestone is converted into a massive garnet

rock, more rarely (where the original limestone was purer) into coarsely crystalline marble. At the south end the deposit shows much black biotite and specular iron (hematite) and magnetite, with some epidote. The outcrop is often a mass of iron-stained quartz, rather hard and dense, and devoid of the honeycomb-structure of gossan. The mine-workings show the ore in irregular bodies (some being 200 ft. thick and twice as long, while others are too small for exploitation) of rudely oval cross-sections, lying in a mass of gypsum, calcite and silica, between the partly altered limestone and the granite. The granite is altered in successive regular shells or layers, seldom exceeding 5 ft. in thickness, which show varying degrees of oxidation. Nowhere were ore-bodies found in immediate contact with the granite. The irregular limestone walls of the deposit show plainly the effect of solutions upon the rock, which is pitted, exhibiting on a large scale the etching produced by an acid solution on limestone. Clay walls, slickensides, and other evidences of faulting, are wanting. There is, therefore, no vein-structure. The ore-bodies consist of copper carbonate and oxides, and occur in a gangue of gypsum and calcite with much iron oxide. It appears probable that the original copper and iron sulphides were oxidized, and, reacting with limestone, formed the copper carbonate and iron sulphate now seen.

Such contact copper-deposits, found at or near the contact between granitic rocks and limestones, are of very common occurrence. They may be of the Kristiania type described by Lindgren, like those of Hornitos, near Mapimi, or they may show later fracturing with definite walls and vein structure, accompanied by enrichment of the deposit. In the former, the ores do not extend into the granite, but appear to be replacements of the limestones. In both forms there is a very general association of the copper-ore with mosaic rock, of garnet, calcite, etc., formed by the alteration of impure limestones. Within my own experience this association has been very marked. Where the deposit or vein, if vein-structure be present, occurs in garnet rock, it is cupriferous; where it is in contact with pure limestones or marbles, the lode is composed of pyrite or barren lode matter.

5. The Guadalupe y Calvo Mines.

The mines at and near Parral and Santa Barbara occur in veins encased in slates or the dacitic tuffs and porphyries which overlie or break up through them. West of the Parral district the Sierra Madre is made up of dacitic and rhyolitic rocks. Later basalts rest, in some places, upon these rocks, but no earlier formations are seen for many leagues. The country is a great plateau, deeply incised by the Rio Verde and other streams, whose cañon walls show good sections of the succession of tuff beds and breccias with later lava-flows that form the summit of the plateau. Throughout the region traversed this dacite plateau shows no mineral veins; it is only where erosion has revealed the underlying andesites or the granitic rocks that ore-deposits are seen. The first rocks of this nature are encountered at Turache gorge, but no veins are seen until the town of Guadalupe y Calvo (Fig. 9) is reached. This settlement is famous in the mining annals of Mexico for its production of gold. The town has a population of 300 or 400 people; it was at one time the site of a Government mint and had a population of several thousand. Geologically it is on the western slope of the Sierra Madre, and is one of a number of prosperous mining settlements found along the western margin of the Sierra Madre plateau.

The gold occurs in fissure-veins traversing altered and fractured andesitic rocks. These quartz-veins are older than the rhyolitic rocks, and only show where the light-colored chalky-white or pink porphyry tuffs have been removed by erosion or mine workings. In part the ores occur in andesitic gangue, but more commonly in true quartz-veins. The amorphous or crypto-crystalline nature of some of the quartz suggests replacement, but comb quartz also occurs. The veins are only exposed on the east side of the creek, the west slope being composed of the dacitic rocks. There are two principal mining properties here,—the Rosario and the Independencia.

The Rosario Vein.

This vein (Figs. 10, 11 and 14) is one of the largest producing quartz-veins of the world. It varies from 60 ft. to 150 ft. in width, and dips with the hillside so that it forms a great reef

fronting the valley, and its exposed wall forms a very conspicuous object (Figs. 12 and 13). It is said to average over 100 ft. across, and where I measured it the thickness was 110 ft. The great open-cut on the vein is 1800 ft. long, 7 ft. deep, and 130 ft. across. Four distinct ore-shoots, separated by low-grade quartz, have been worked. The low-grade ore now forms the enormous dump-heaps seen at the mine; and, despite the fact that the people of the town have largely obtained a living by picking over this dump, it is said to be all good cyaniding ore, "averaging better than $10 per ton." The vein has a NW. and SE. course, and dips west. The vein has been worked on one hill to a depth of 430 ft., but a vein of this magnitude will probably not play out at such shallow depths.

The Rosario vein was discovered in October, 1835, by a Tarahumar Indian from Nobogarne, when it was shown to some miners from the Refugio mine, 30 miles south of the Rosario. The extraordinary size and richness of the vein caused a rapid influx of miners to the locality, and two months after the discovery there were 2000 people encamped about it. The vein was located by various individuals, but soon passed, by purchase and debt of the owners, into the hands of the Ochoa family. In 1836 the Ochoas leased the property, in two parcels, to two companies, organized with English capital, and known as the Guadalupe Co. and the Zorilla Co. respectively. The Guadalupe Co. worked the western part and the Zorilla the eastern part of the property. These companies were obliged to work under lease, as the former Mexican law did not permit foreigners to hold real estate. The terms of these leases are said to be in the mining records, and provided for a royalty of 25 per cent. for four years and $50,000 for eight years; the lease expired in 1847 or 1848.

Under these companies the vein yielded enormous amounts of gold and silver, so that in October, 1842, a decree was secured from the Government permitting the erection of a mint (Fig. 15) at the mine. The records of this mint have been destroyed by fire, but custom-house records show that coinage began in July, 1844, and that steam-power was introduced in 1847.

The recorded output of the Rosario for the years 1838 to 1846 is $16,000,000, but owing to the heavy tax upon bullion

and the ease with which the tax was evaded, reliable estimates place the total output from the discovery of the vein to the closing down in 1847 at $40,000,000. The mine was, during these years, worked by the most primitive methods, and the tailings show that a large part of the value was lost. The ore was, of course, carried on men's backs to the surface and then packed on burros to the various crude reduction-works located many miles down the creek, where it was treated in *tahonas*, with an overshot water-wheel furnishing the power.

In 1847 large quantities of water were encountered; and, the working expenses being very greatly increased, the English companies attempted to renew the lease for a rental of $30,000 a year, a proposal that was indignantly refused by the owners. Personal differences, added to the refusal, led to the abandonment of the property by the English company, who removed to the silver mines of Guanacevi. From this time to 1883 no development work was done. Various Mexican miners robbed the pillars of rich ore left in the workings, "gophered" the rich streaks of ore, and sorted the dump.

In 1883, Judge Flipper, representing the Guadalupe M. and M. Co. organized at Memphis, Tennessee, secured the property under an agreement with the Ochoa family, who reserved a one-fifth interest and were to receive one-fifth of the gross output of the mine. This company operated the mine until 1887,—erecting a ten-stamp mill, and sinking a new shaft, from which a crosscut was driven to the vein and drifts run out from the old shafts. In one year this company shipped $113,000 in gold; but the manager was robbed of nearly $20,000 while taking the bullion across the mountains, and, as a consequence, the property was abandoned by the company in 1887 and reverted to the Ochoas. At that time the Mexican mining laws required properties to be worked by six men for six months of each year; this the Ochoas failed to do, and in 1889 the property was denounced by four Americans, who obtained title from the Federal Government. With three Mexican merchants, admitted as equal partners, the property was operated and the ore treated in a stamp-mill with pan amalgamation. In 1892, operating under lease, two of the partners cleared over $100,000 in 22 months, working on ore from the dump-heap and from the rich pillars left in the workings.

Meanwhile the ownership of the property passed into the hands of Tibuceo Garcia, and was sold by him, in 1895, to the Rosario Mining and Milling Co.

The Independencia.

The Independencia property includes a group of claims situated east of the town of Guadalupe y Calvo. The claims cover a complexity of veins shown in Fig. 16. The main workings are entered by a tunnel near the mill, and include shafts and drifts on the Independencia ledge. The vein outcrop consists of porous white quartz, which is rusty and drusy in some places. The ledge runs a little north of west, and has been quarried by open-cut and stoping from below. These workings show the vein to be 8 or 10 ft. wide, with a pay streak from 1 to 5 ft. across, showing a well-defined sinuous wall. The ore consists of white quartz and red jasperoid carrying pyrites, and rarely free gold. Some of the ore carries high values in silver, but no recognizable silver minerals were seen, the richest ore showing a black clouding of the quartz. The vein-filling is finely crystalline, and shows none of the coarse texture and comb-structure of a filled fissure, its nature being that of replacement quartz. Where crystalline quartz is seen, it is secondary, and cements fragments of shattered original vein-filling. A banded structure is rarely seen, and occasionally the vein-filling shows fragments of an andesitic breccia, the rock being altered and of a greenish-yellow color. So far as seen, the vein is nearly vertical. Its surface continuity is interrupted by a patch of rhyolite tuff, as shown in Fig. 16.

The workings consist of three tunnels with drifts, and expose the vein for a vertical depth of 220 ft.; two winzes of 26 and 30 ft. depth, respectively, prove the vein below the lower tunnel. The following assays show the general character of the ore on the Cuauhtemoc vein: gold, 0.04 oz. to 5 oz. per ton; silver, 3.20 oz. to 167 oz. per ton. An average of 24 assays from the various faces gave: gold, 1.18 oz. per ton; silver, 16.62 oz. per ton. The ore varies in appearance. The pyritic ore is commonly reddish quartz, with veinlets of white and gray quartz. The silver-ore contains finely disseminated galena, with zinc-blende, and occurs in a

mixture of dark gray, white, and amethystine quartz. Chalcopyrite occurs in minute specks. The rich gold-ore shows dull greenish secondary quartz, often in botryoidal forms, filling cavities; the primary ore often shows rusty gold, suggesting decomposed telluride ores. It also occurs associated with minute specks of copper pyrites and zinc-blende. The rocks are altered porphyritic andesites.

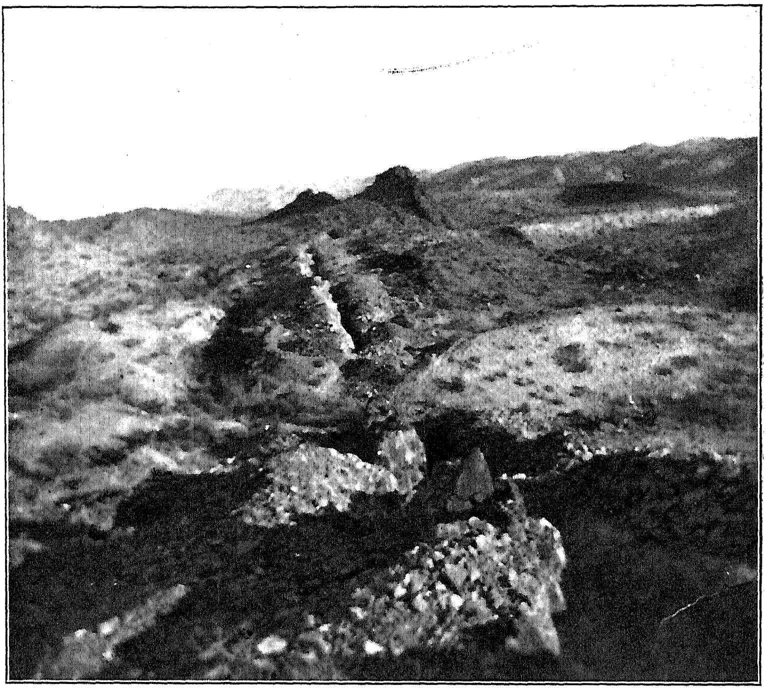
6. La Cumbre Mines.

West of Guadalupe y Calvo the Sierra Madre region differs in topography and geology from the region east of the town, where it is a slightly dissected plateau of bedded rhyolite and dacite porphyries. Westward the Sierra plateau is dissected into a maze of mountain ridges and peaks in which the older igneous rocks, the granites, diorites, and the andesites constitute the lower part of the mountains; the younger lavas cap the summits and cover relatively small areas. This region contains many mineral-bearing areas, that of San José de Gracia being the best known. Los Angeles, San Fernando and the Trigo silver-mines are a few of the places nearer to La Cumbre. This village, situated on a mountain-top west of the Bazonopa river, is supported by the Fortuna and Guadalupe mines. The country is extremely rugged, the mountain-tops having an elevation of nearly 8000 ft., the village of 6800 ft., and the river of 3200 ft. above sea-level.

The older rocks are andesites, altered breccias and lava-flows, baked and recrystallized near the diorite intrusions which cut through them. These diorites are coarsely granular, and in appearance are dark-colored granites. Both diorite and andesite were eroded, at the period when the rhyolite-dacite eruptions began, into a mountainous country as rough as that now seen, so that these recent rocks now covering the summits form the mountain spurs, and are cut into deep cañons by the Bazonopa river. Before the rhyolite intrusions occurred the country was extensively fissured, and quartz-veins were formed traversing the andesites and granites. These veins are particularly large and well-developed in the Guadalupe and Fortuna properties at La Cumbre; and though they pass under the rhyolite caps, and their absolute identity is lost, the group of veins of which the Fortuna is a part can be traced for several miles.

Their course is nearly east and west (N. 70 degrees E. mag.), and the dip is toward the south. The Fortuna vein shows from 8 to 32 ft. of quartz, but the hanging- and foot-walls show decomposed rock, and crosscuts show much alteration for many feet on each side of the vein. This alteration has caused the complete disappearance of the dark-colored minerals of the rock whose iron has united with the sulphur of the circulating

Fig. 1.

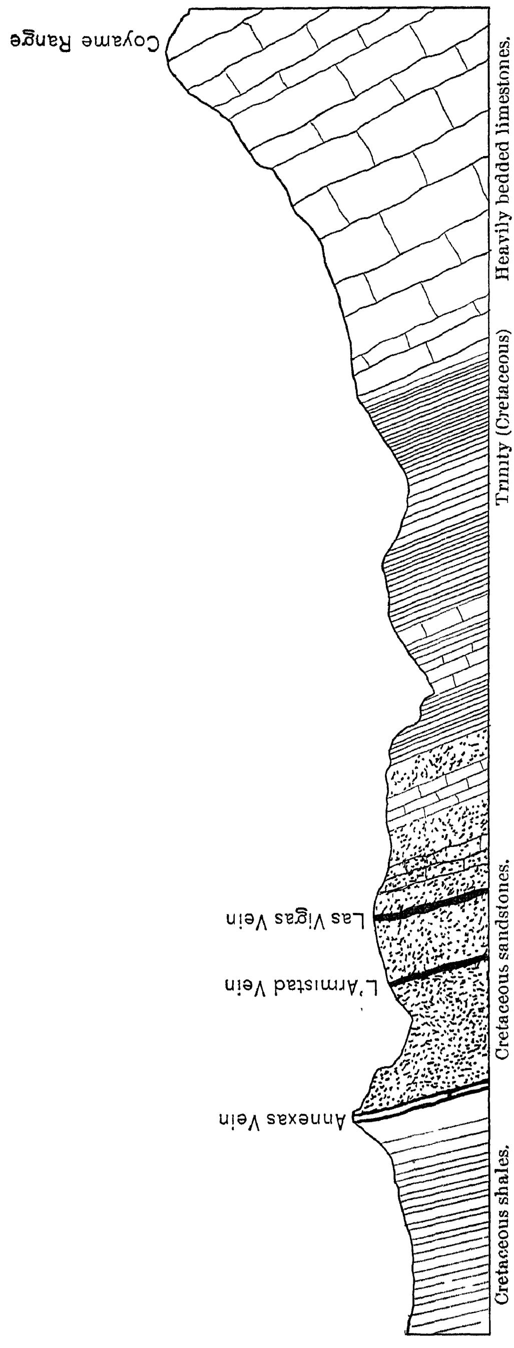


Open-cut on Las Vigas copper-vein, near Coyame and Rio Conchos, Chihuahua, Mexico.

water and formed pyrite, partly in little veins, but mainly as disseminated crystals.

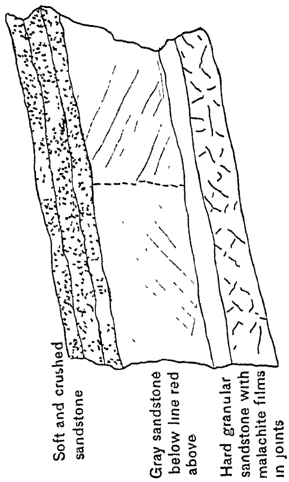
The vein outcrops are well-defined reefs, which usually stand in relief above the slopes. The vein-filling consists of white and blue quartz, with pyrite scattered through it, together with some chalcopyrite and zinc-blende. The capping of oxidized ore is very thin, the sulphides being encountered but a few feet below the surface. Bunches of very rich ore sometimes

FIG. 2.



Ideal E. and W. cross-section through Las Vigas veins, near Conchos river and Coyame, Chihuahua, Mexico. Looking north. Veins in solid black.

Fig. 3.



Section of Las Vigas vein in open-cut.

Fig. 4.

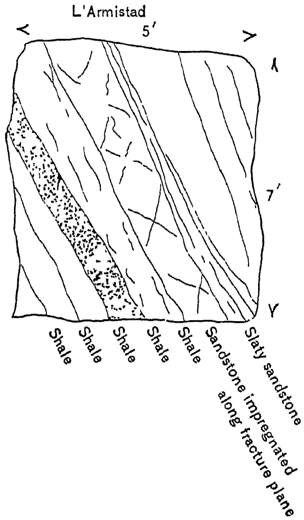


Fig. 5.

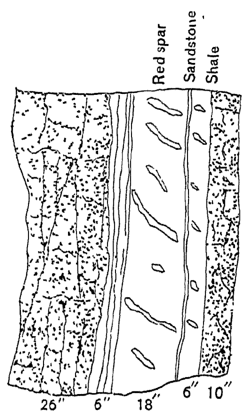
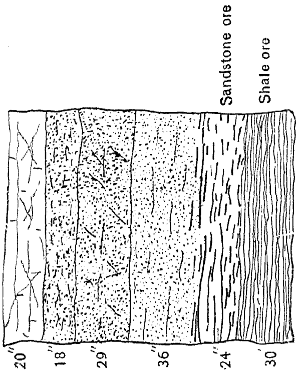


Fig. 4.—Section of L'Armistad vein, Las Vigas mines. Consists of sandstone layers, with thin partings of shale, shown by lines in figure. The ore consists of malachite, azurite and chalcocite in bunches up to 3-in. diameter and films on fractures, and is associated with calcite.

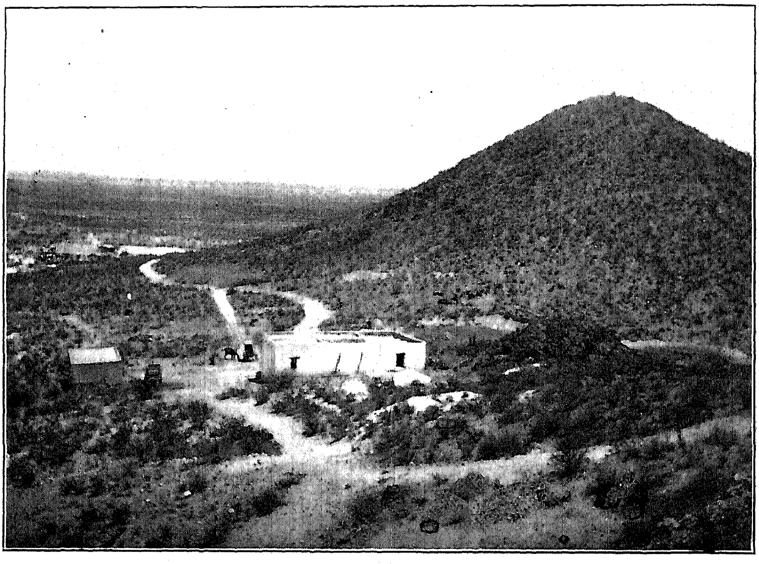
Fig. 5.—Section of Annexas vein, Las Vigas mine; 26-in. streak (on left) of hard barren sandstone; 6-in. black shale (barren). The ore-bed is a sandstone cracked by differential slipping, and the cavities filled by red calc-spar. The ore occurs both in spar and sandstone. Thin shale-bands separate the ore-layers.

FIG. 6.



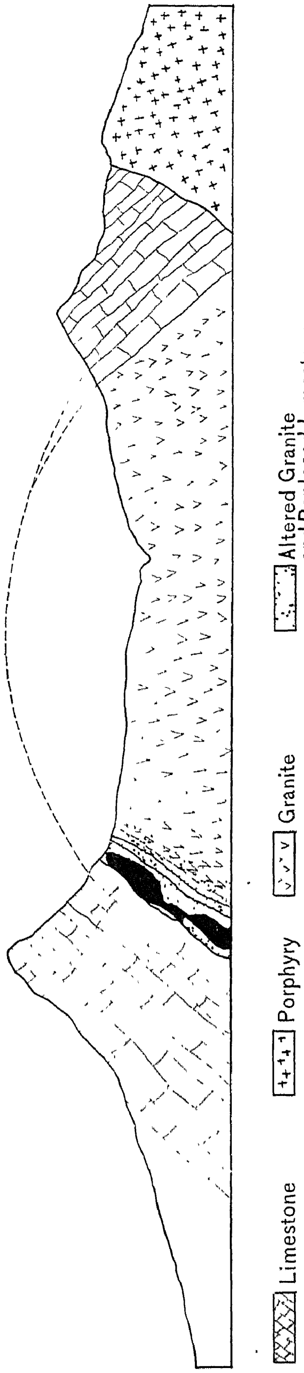
Section of Las Vigas vein; 20-in. streak on left side is unaltered gray sandstone; 18-in. streak is a shaly sandstone, fractured and showing films of copper-ore in cracks; 29-in. streak is a very shaly sandstone, with ore in fractures shown by black dashes; 36-in. streak is massive sandstone carrying very little ore; 24-in. streak is the main ore-layer, consisting of sandstone impregnated with copper-ore (glance). The richer ore occurs in streaks shown by black lines; 30-in. band is shale, with films and nodules of ore.

FIG. 7.



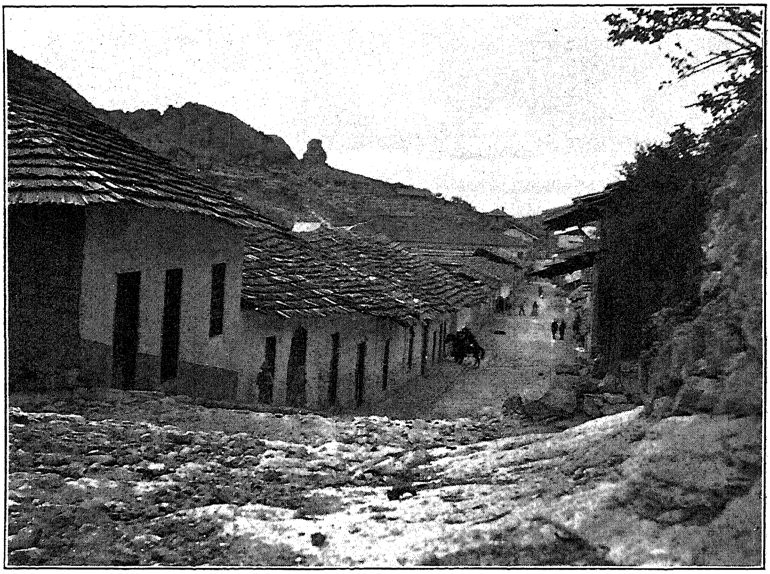
Jibosa copper-mine, near Jimenez, Chihuahua. Mine-workings on left and back of house. Quartz outcrop on right of house. Hill of Cretaceous limestone and shale. Foreground of granite.

FIG. 8.



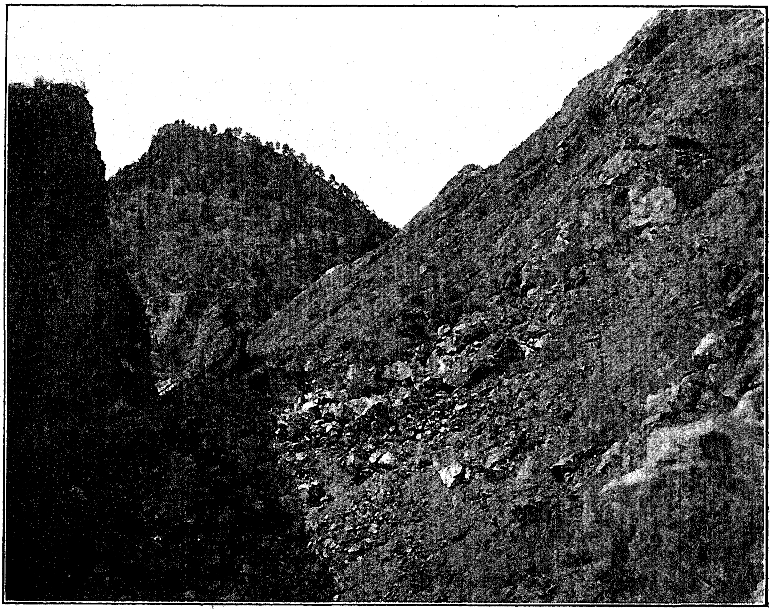
Ideal cross-section through Jibosa mine, and granite boss, Jimenez, Chihuahua, Mexico. Solid black represents copper-ore bodies.

FIG. 9.



Guadalupe y Calvo. Dacitic tuffs in foreground, and forming pinnacle and ridge in background.

FIG. 10.

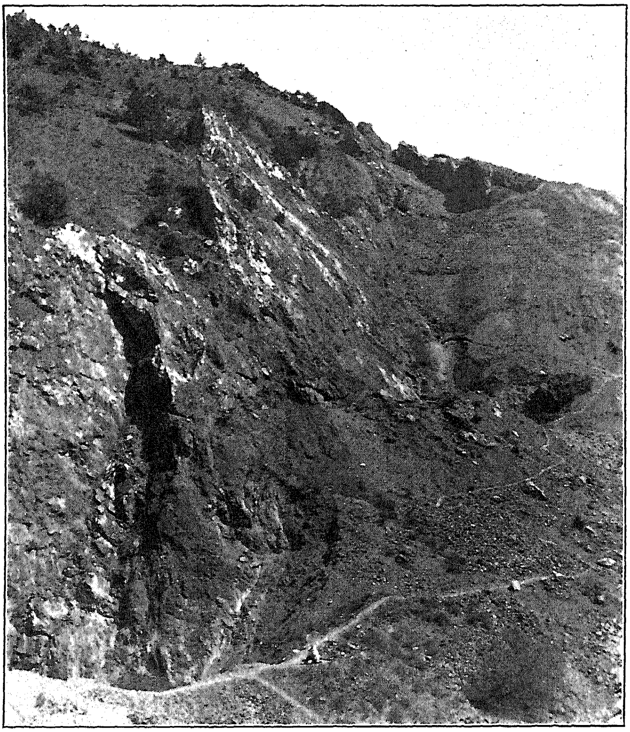


Open-cut workings on Rosario vein, Guadalupe y Calvo, Chihuahua.

FIG. 11.

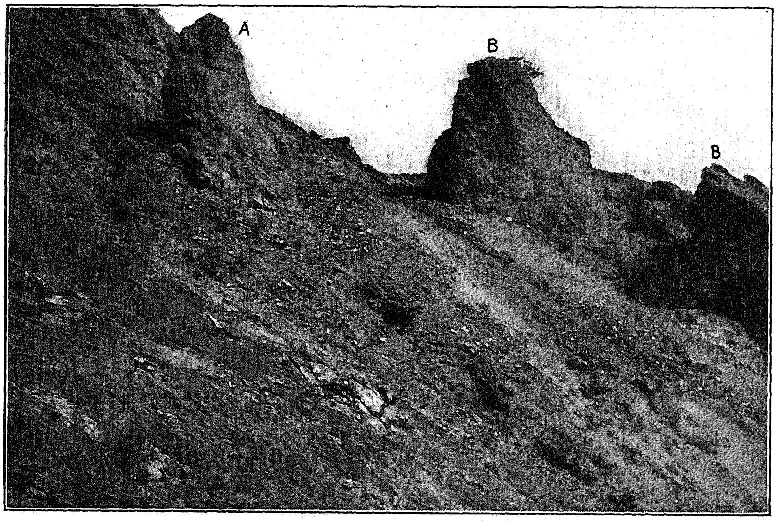
Topographic sketch showing outcrop of Rosario vein and its relation to town, Guadalupe y Calvo, Chihuahua.

Fig. 12.



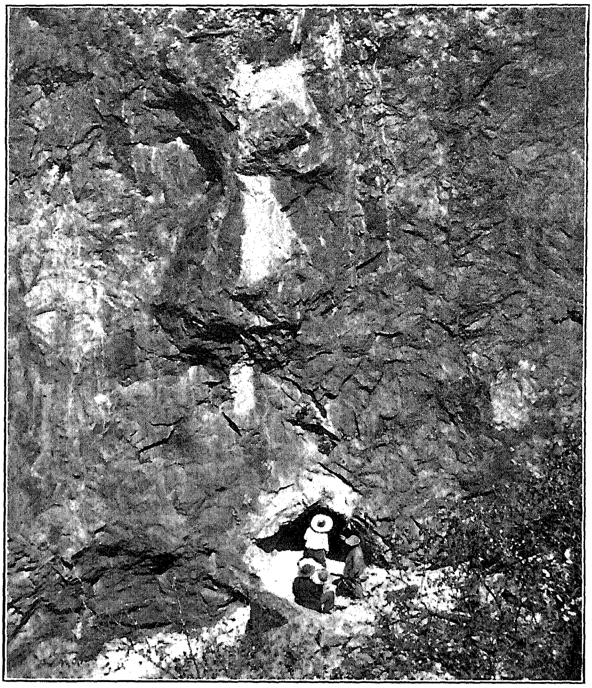
Foot-wall streak, outcrop of Rosario vein, Guadalupe y Calvo, Chihuahua, Mexico.

Fig. 13.



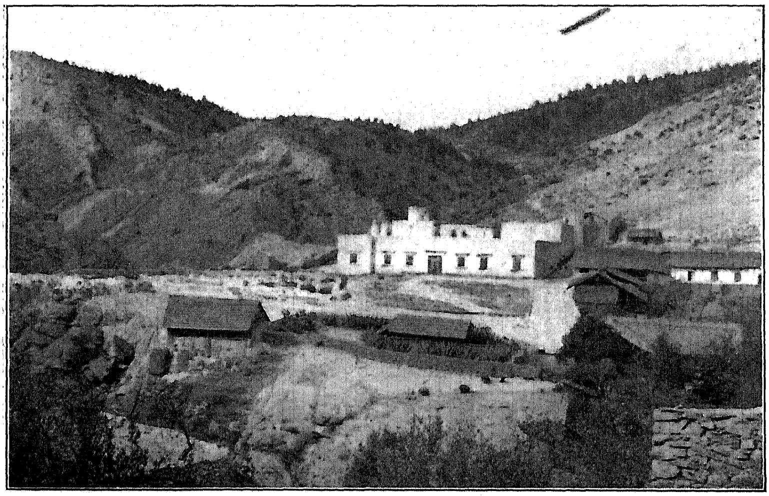
Outcrop of Rosario vein. A. Foot-wall streak. B. Hanging-wall streak.

FIG. 14.



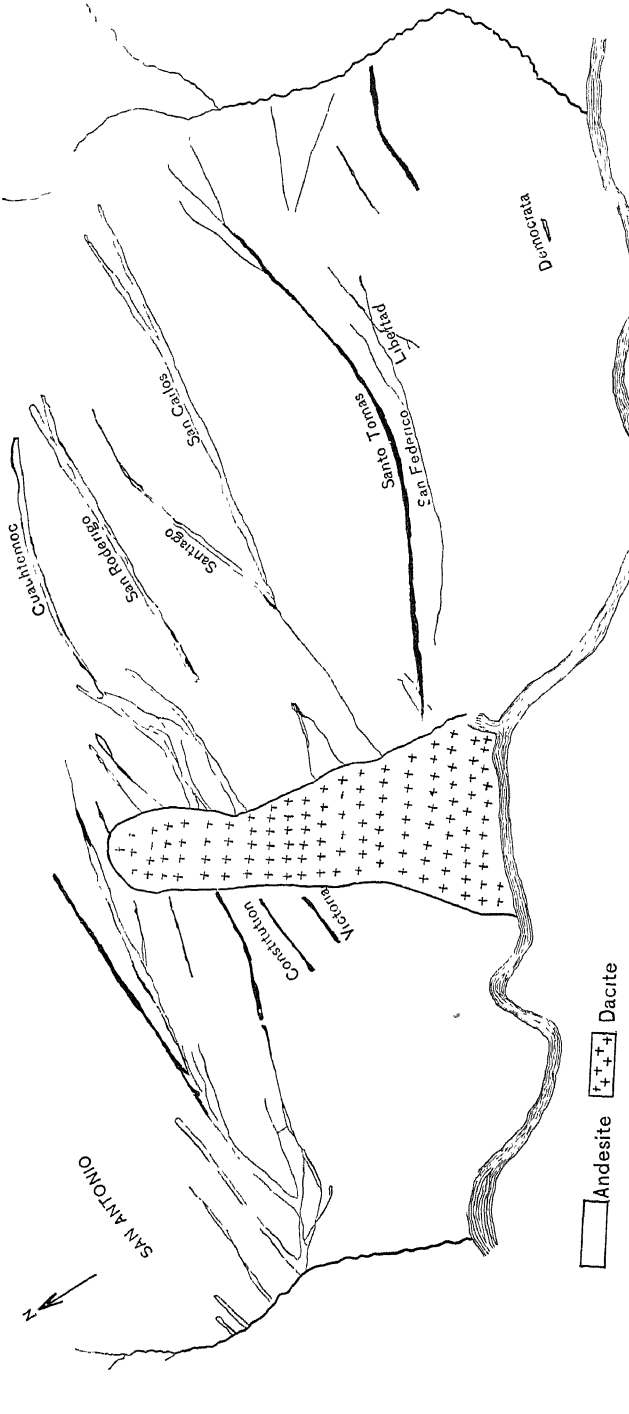
Face of quartz, Rosario vein, Guadalupe y Calvo, Chihuahua, Mexico.

FIG. 15.



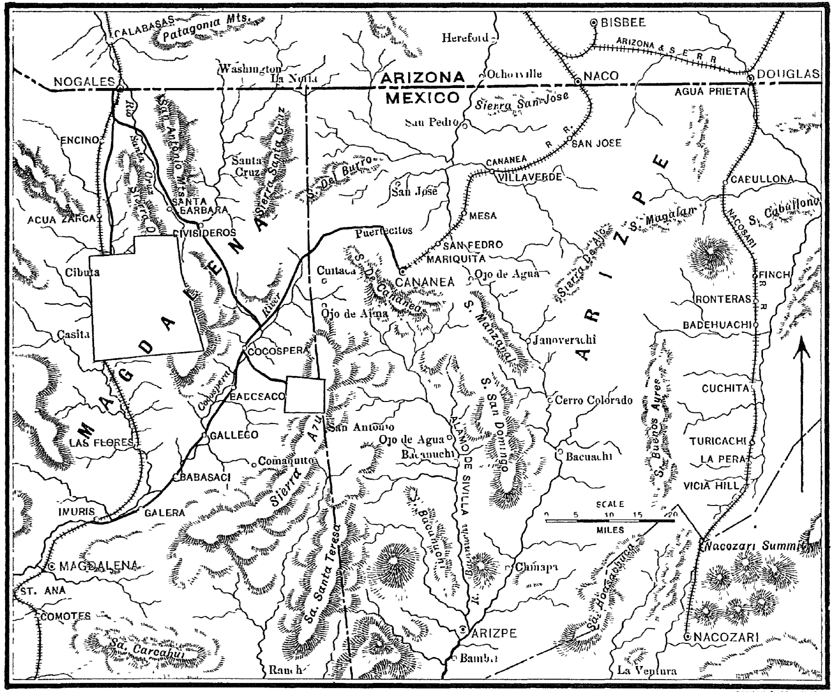
Old mint at Guadalupe y Calvo, Chihuahua. Outcrop of Rosario vein seen in background on left. Dacitic tuffs covering vein on right, and forming plateau on which buildings stand.

FIG. 16.



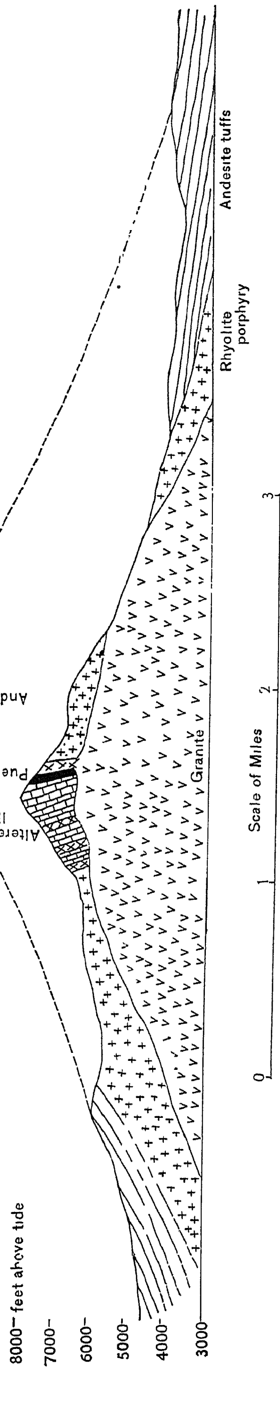
Independencia group of veins, Guadalupe y Calvo, showing dacite capping veins and andesitic rocks.

FIG. 17.



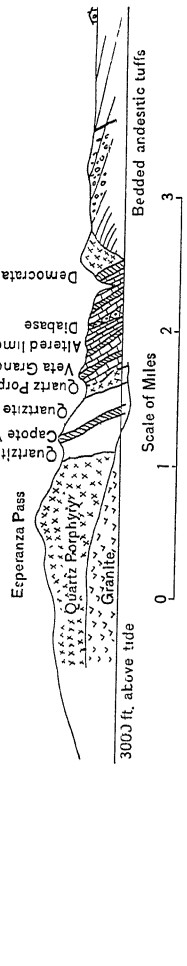
Sketch map of part of Northern Sonora, Mexico. The large area blocked out is the Hays Cons. M. & M. Co.'s tract in the Sierra Pinitos; the smaller area is in the Sierra Azul. The solid black lines represent the wagon-roads.

FIG. 18.



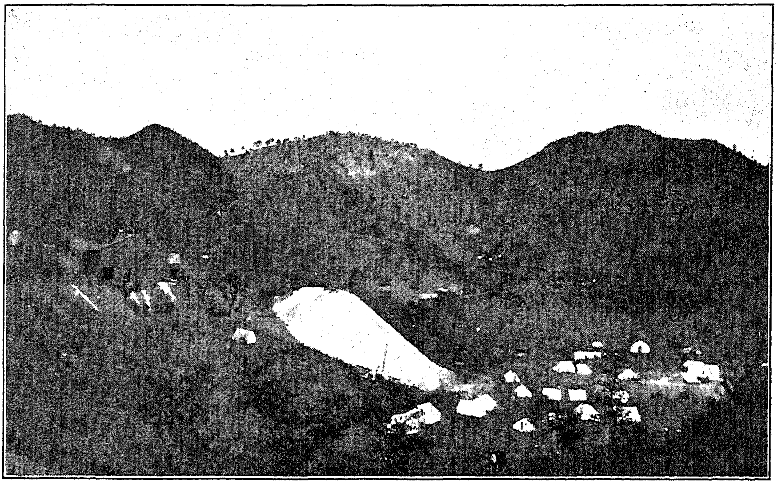
Hypothetical cross-section through Cananea range, showing supposed central mass of granite, cap of altered limestones, andesite, etc., and flanking tuffs.

FIG. 19.



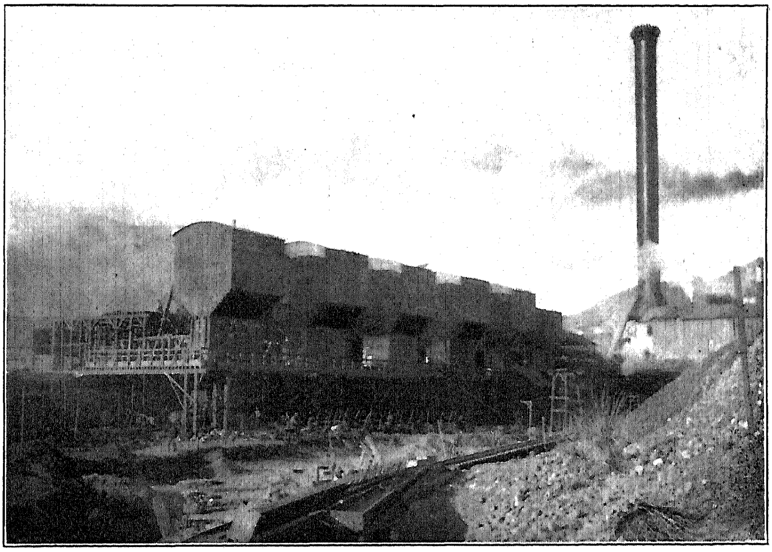
Ideal cross-section through Ronquillo group of mines, Cananea.

Fig. 20.



Capóte mine, Cananea mountains, Sonora. Main crest of range in background. Hill back of tents is outcrop of one of the great veins. Ore-bins of Elisa mine in mountain gap.

Fig. 21.

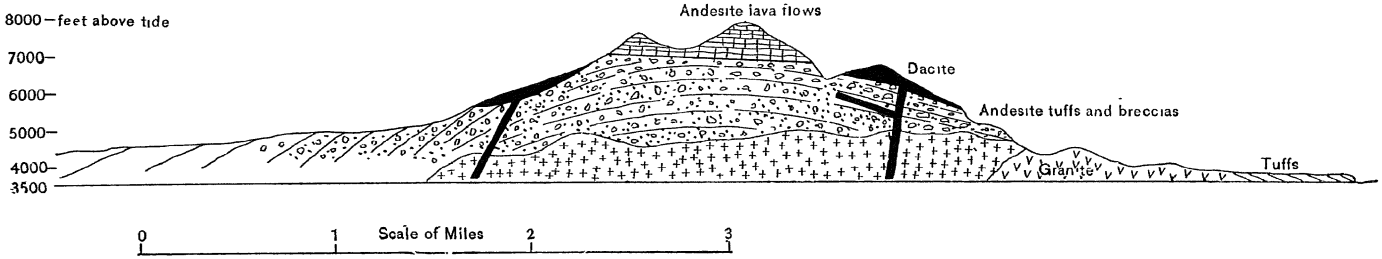


The blast-furnaces of the Cananea Cons. Copper Co. (Greene) at Ronquillo. The excavation is for the Bessemer plant, now completed, and in operation.

FIG. 22.

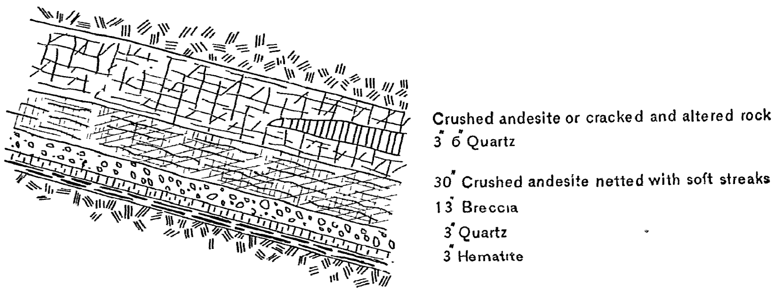
Pinitos range, Magdalena district, Sonora, Mexico, showing character of topography of eroded dacitic and andesitic rocks. (Snow-covered; north, pine-clad slopes.)

FIG. 23.



Hypothetical cross-section through center of Pinitos range, Magdalena district, Sonora. Central core of mountain of massive andesite porphyry capped by fragmental andesitic rocks, overlain by lava-flows and intruded by dacite.

FIG. 24.

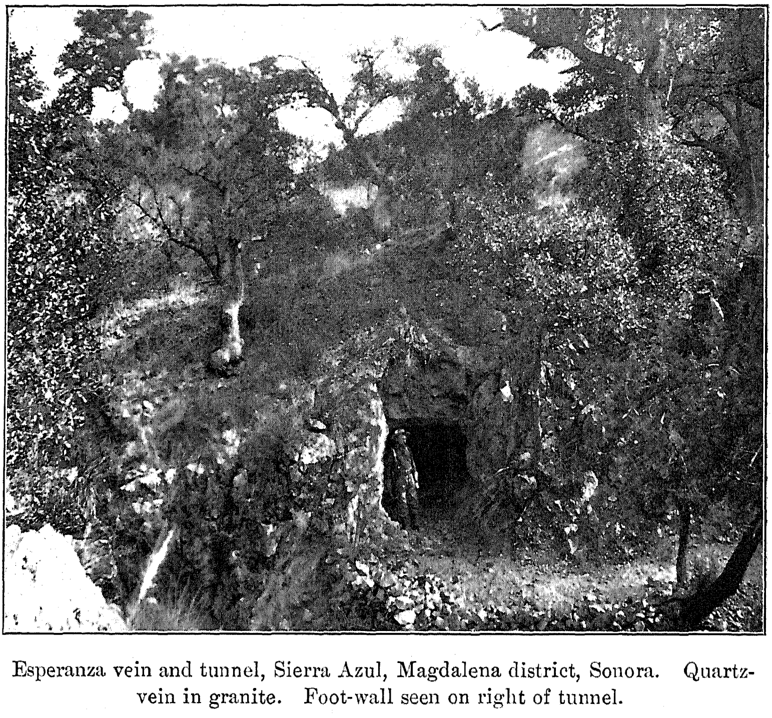


Vein-structure, Independence No. 2, Sierra Pinitos.

occur, and usually with a green quartz, colored by a mica, whose appearance strongly suggests the vanadium-mica, roscoelite, which, according to Lindgren, is commonly associated with the richest gold-ore of California. This ore and the rosy ore of somewhat lower value often occur as shells encasing nodular masses of zinc-blende.

The character of the quartz, the lack of comb-structure, and the evidence of replacement of fragments of the crushed

Fig. 25.



Esperanza vein and tunnel, Sierra Azul, Magdalena district, Sonora. Quartz-vein in granite. Foot-wall seen on right of tunnel.

granite and andesite, indicate that the vein is largely formed as the result of replacement. The decomposition of the country-rock confirms this, and in the coarse-grained granite the character of the vein is identical with the copper-veins of Butte, Mont., which are typical examples of replacement-veins.

7. Palmarito Mine in Sinaloa.

The western part of Mexico in the Tierra Caliente of Sinaloa and Sonora is a coastal plain diversified by isolated mountain

ranges and groups of hills. The higher parts of this plain show folded slates and sandstones covered by fragmental volcanic accumulations of andesitic tuffs and conglomerates. These rocks are cut by granitic intrusions, while the higher hills and moúntainous areas are commonly composed of dacito-rhyolites or rhyolite-porphyries. Near the little town of Palmarito, about 30 miles north of Culiacan, and as many miles from the shore of the Gulf of California, there is a sharp crested hill that rises 300 ft. or more above the plain. The hill is covered by angular blocks of reddish rock, and shows a steeply inclined wall as the side of a great reef of silver-bearing porphyry. This reef is a dark, purple-gray porphyry, with rather chalk-like texture. It is clearly a breccia, and the quartz of the reef shows distinctly, by variations of color, the replacement of the angular fragments, as well as their more or less complete decomposition. The ore also shows a conglomeratic structure, in which rings or shells of quartz enclose pebbles of altered porphyry. A study of thin sections of these rocks has been made by my friend Prof. Alexander N. Winchell, of the Montana State School of Mines. He finds that the foot-wall is a trachyte, carrying some plagioclase and pyroxene. The main body of the hanging-wall is a quartz-syenite of finely granular texture, showing a little pyroxene. The ore itself is a decomposed trachyte carrying wagnerite, hematite and a little pyroxene; the more siliceous ore consists of granular quartz carrying the minerals last mentioned.

The ledge is said to be 135 ft. to 150 ft. across. It has an east and west trend, and dips at 30° N. This ore-bearing reef is underlain by solid blocky porphyry, of different texture and appearance from the ore-bearing breccia. The values occur in pay-streaks of rich ore, and only those carrying silver were worked through the entire thickness of 135 ft. The ore is mostly dry, the silver occurring as silver sulphide and its decomposition products, but there are bunches of lead-ores which are sorted and shipped to Mazatlan. The entire reef is said to average 15 oz. per ton in silver, and is certainly well mineralized, though no samples were taken. There is no question but that water will be encountered below the level of the plain, and that the ore will change to a sulphide.

The workings, in December, 1900, consisted of an open

quarry and of two drifts of 15 to 20 ft., with an upraise of 100 ft. or so on a flat pay-streak. The ore is mined by hand and packed down on the backs of burros to the mill at the foot of the hill. The five-stamp-mill crushes the ore dry, and no screens are used in front of the mortar, the discharge being through a slit 1 in. wide under a board placed where the screen is usually found. The discharge passes over a gently inclined screen, the finest going directly to the roasting-furnace and the screenings back to the stamps. By this simple device 12 tons of ore are crushed each day, although the stamps are small and in bad condition. The ore is dried in a brick reverberatory furnace before crushing. The pulp is roasted and then leached with hyposulphite, the silver sulphide filtered through cloth, and the resulting mineral sun-dried and roasted to free it from sulphur before shipment. The ore milled carries 28 to 31 oz. of silver per ton, with an extraction of 80 to 85 per cent., as shown by the company's books. The output is 4700 to 6000 oz. per month, the shipments for sixteen months aggregating 125,000 oz. (December, 1900.)

8. The Cananea District.

Within the past two years the Cananea and the Nacosari copper districts of Northern Sonora have been added to the list of great copper producers of the world. In the progress of this work, railways have been built and the districts mentioned have awakened from almost mediæval quietude and simplicity to the nervous activity of busy, wide-awake communities. The result has been that there is an active and vigorous search for desirable ore-deposits of every kind, and the great mineral wealth of Sonora has been brought to the attention of the world at large.

The part of Sonora noted in this paper lies near the International boundary in the vicinity of Nogales, and of Bisbee, Arizona. The grassy plains along the border line have an elevation of 4600 ft. above tide, and above these broad llanos the mountains rise abruptly to an elevation of 3000 ft. or more. The region does not present the usual desert aspect common in Arizona and Sonora, as the elevation and geographical position give it a rainfall considerably in excess of that normal to the desert as a whole.

The accompanying map (Fig. 17) shows the relative position of the three mountain ranges, namely, the Sierra Cananea, Sierra Azul, and Sierra Pinitos, which were visited while the writer was engaged in a professional examination of the copper- and gold-mines of those districts.

The predominant rocks of this part of Sonora are volcanic tuffs and breccias ejected from vents whose cones are now dissected and form the mountain ranges. The volcanic ejectamenta also cover a large part of the intervening valleys, and have furnished the material for extensive alluvial deposits. Massive igneous rocks occur in all the ranges, underlying the tuffs and cutting through them. The igneous rocks present peculiarities of composition which show that the region belongs to the Arizona petrographic province. The older rocks are andesitic and andesitic breccias cut by later massive granitic rocks, and covered by dacitic rocks and tuffs.

In a paper on the geology of Sonora, Mr. E. T. Dumble* has given formation-names to such volcanic accumulations. While this is warranted where the igneous rocks occur interbedded with fossiliferous strata, it is not, in my opinion, applicable to the rocks seen at Nogales or in the region southeast of that town, embracing the Pinitos, Azul and Cananea ranges, and the country traversed by the wagon-road. An intimate acquaintance with similar volcanic phenomena in the United States convinces me that it is neither safe nor wise to assume similar ages for similar appearing volcanic accumulations when stratigraphic or paleontologic evidences are wanting.

The Cananea Copper-Deposits.

The Cananea deposits are situated in the range of that name, 30 miles south of the International boundary, and about 45 miles southwest of Bisbee, Arizona.

The locality is now accessible by rail from the main line of the Southern Pacific at Deming or Benson, over the El Paso and Southwestern to Naco on the International boundary, where connection is made with the Cananea railroad. This railway traverses an open, well-watered prairie land, the average elevation of which is 5000 ft. above sea-level.

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* *Trans.*, xxix., p. 122 *et seq.*

The mountain range rises abruptly from the broad *mesa* flats, which though apparently level, have a nearly uniform 2 per cent. grade. They are trenched by the streams, whose diverging branches have cut broad and shallow valleys in the basal mountain slopes and concentrate in trunk channels which are a hundred feet or less below the level of the plain. Nearing Cananea, the broad and gently sloping plain shows a scattered growth of *yuccas* in a stony or gravelly soil, replaced, as the town is reached, by scrub oak trees.

My observations on the Cananea range were made while riding over the trails to Puertecitos and returning by wagon-road, so no pretension is made to accuracy in the accompanying cross-sections (Figs. 18 and 19), which are given as diagrammatic representation of hasty observations.

The mines are situated on the northern slopes and watershed of the Cananea range, a group of mountains 6 to 10 miles wide and about 25 miles long, running in a general northwest and southeast direction. The mines are located in the southern half of the range upon a great mineral belt or zone, running with and along the range, from its southern extremity to the deep gap that divides the mountains into two distinct portions. This range consists of the denuded and dissected remains of an old volcano. Near the central dividing gap there is a great mass of hornblendic granite occupying the center of the old volcano, forming its core, and encircled by andesitic porphyries of various kinds, and by massive crystalline rocks of similar composition.

The granite core is seen near Puertecitos, surrounded by massive andesitic and dioritic rocks. The main crests and summits of the range consist of quartzites, hornfels, marble, adinoles, etc., formed from sandstones, shales and limestones, and cut by andesites and quartz porphyries. The character of these rocks and their relation one to the other show the region to have been one of intense volcanic activity. The bedded andesitic tuffs and breccias, forming the lower foothills and *mesas* to the east of the range, are the ejected rocks and andesitic ash of the old volcano, whose core is now dissected and carved into a mountain range without a suggestion of its old form. The outlying fragmental rocks are well exposed, but the complex of altered sediments and massive igneous rock, forming the moun-

tains, presents few good natural exposures of the rocks, though there are many outcropping ledges of the metal-bearing vein-stuffs. The wagon-roads and the narrow-gauge railway almost encircle the range, and give excellent exposures of the rocks, which are supplemented by the sections in the mine openings. It is evident, from the character of these rocks and their relation one to the other, that a volcano broke out in a mountainous mass of Carboniferous limestones and shales, which were covered up by volcanic ashes and lava flows, and later sufficiently eroded to expose the deeper rocks in the mountain area.

Distribution of the Rocks.—Across the range west and northwest of the Capóte group of mines the quartz porphyry forms the mountain slopes, its white, shelly *débris* being very conspicuous.

From the Capóte group an excellent wagon-road has been cut over the range, and along the western slopes for four or more miles, to the sawmill at the head of the gulch. Along this road the porphyry gives place northward to greenish garnet-epidote belonging to the altered limestone series, and cut by diabasic dikes. These rocks prevail as far as the sawmill, and probably from the divide between this gulch and Elenita, though good exposures are lacking. It is not until the dump of the Elenita is reached that fairly fresh rock is seen. The rocks at the Elenita consist of altered limestone, olivine and basalt.

Between the Elenita mine and the Puertecitos group, the most northerly group of the company, a wagon-road has been blasted out of the side hill, exposing fine sections of hornstone, adinoles, impure marbles, and other rocks of original sedimentary origin, altered by contact metamorphism. These rocks show distinct bedding-planes, adjacent beds often being of strongly contrasting color and composition. They are cut by dikes of white aplitic granite and the strata dip north. The outcrops and road-cuttings show much copper, mostly as green stains.

The Puertecitos mines show great outcrops of garnetiferous rock carrying copper carbonates, oxide, and the native metal. That this is derived from veins of chalcopyrite ore is shown by the working tunnel of the Cananea mine, where a vein 30 ft. wide consists of an upturned stratum of altered impure lime-

stone, heavily charged with chalcopyrite and zinc-blende. This bed occurs beneath a layer of white marble. The entire section seen along the road is one typical of contact metamorphism in which the pure limestones have changed to marble, and the impure argillaceous limestones and the shales to mixtures of garnet, epidote-calcite and other contact minerals.

From Puertecitos to Ronquillo the wagon-road follows the creek gorge for several miles, and then crosses the low hilly country at the foot of the mountains. The upper gorge, near the mines, is cut in a gray-brown dioritic porphyry, which is exposed in the mine-workings adjacent to the ore-body. A cañon extends for a mile or so through this rock, and then follows the contact between the diorite porphyry and a normal granite, the latter rock forming a considerable area to the northwest. Farther down, the gorge leaves the contact, and is cut in andesitic porphyry, whose large white feldspar crystals are very conspicuous. This forms the lower mountain slopes until covered by the tuffs and breccias that form the foot-slopes and flanking *mesas*. These tuffs are usually of a purple or gray color, dip 15 degrees to 20 degrees eastward, and vary in texture from coarse conglomerates to fine sandstones. Certain beds, as, for example, the gray tuff seen overlying the purple tuff quarried at the smelter, are traceable for several miles.

Age of the Rocks.—I did not see any unaltered limestones in the Cananea mountains. Fossils, if present originally, must have been entirely obliterated in the crystallization and formation of new minerals which has resulted from very pronounced contact metamorphism. That this series of sediments aggregated several thousand feet in thickness is certain, as the bedding-planes are preserved by the marked differences in mineralogical composition. Fossiliferous limestones of Carboniferous age are seen at Naco Junction, 40 miles northeast of the Cananea, and it is believed that in part, at least, the rocks at the mines are of that age.

The Ore-Deposits.—The ore-bodies of the Cananea consist of great masses of chalcopyrite (and its secondary products,—glance, malachite, cuprite, native copper, etc.), occurring in the altered sedimentary rocks, and in veins or fractures in which secondary concentration has occurred. The contact-bodies are not, however, confined to the immediate proximity of the

eruptive mass, and are therefore not of the true Kristiania type. The rocks consist of series of beds dipping east about 60 degrees, the original bedding of the sediments being clearly recognizable, since original differences in composition have produced different mineral composition. This is especially well shown on the west side of the mountains, along the wagon-road from Capóte to the sawmill, and also along the road from Puertecitos to the Elenita mine.

There is a belt of these contact metamorphic rocks extending from the Cobre Grande on the southeast to the Puertecitos on the north, a distance of about 8 m. These rocks do not all contain ore, but it occurs localized along favorable beds. This mineralization is especially great at the southeast end of the range. As the outcrops have been weathered and leached, they now form great ridges of gossan. The Democrata is the most easterly, and between this and the Capóte vein there is the Veta Grande, a big iron vein, and a large number of small veins in the limestone series, while in the porphyry and quartzite to the west the Oversight and Capóte mines are found (Fig. 19).

The Capóte ore-body consists of a mass of crushed porphyry, altered to a white, clayey material, and carrying scarf-like masses, strings and bunches of soft black copper-glance, with some residual pyrite. The southwest and southeast parts of the ore-body consist of a shattered mass of quartzite, whose joints, fissures and interstices are filled by ore. This crushed material has all the characters of an interfault mass, but no boundary fault-slips were observed; and where the boundary of the ore was seen, the transition to solid and lean quartzite or pyritized porphyry was very abrupt. The evidences that the glance is of secondary origin are clear and conclusive, both in the faces seen in the mine and in thin sections of the ore, where the disseminated pyrite grains (of an altered porphyry, forming a dike in the quartzite of the ore-body) are partly replaced by glance. The ore-body is very large, measuring 275 ft. by 135 ft. on the 100-foot level, and 165 ft. by 100 ft. on the 200-foot level. The ore is soft, as much of the porphyry is rotted, and heavy timbers in square sets are used, and the space filled with waste, as in the Butte practice. Much of the ore will run 15 per cent. as mined. In the rock-cuts along the narrow-gauge

railway the true nature of several of the lesser veins is recognizable as altered strata impregnated with chalcopyrite, with small amounts of galena and blende.

In the Cananea district the vein outcrops are the most prominent features of the landscape in the vicinity of the mines now being worked. The enormous masses of iron-ore, the gossan caps of the veins, form high ridges of rough brown rock, traceable for long distances across relatively smooth slopes. Where the streams have cut across these vein outcrops, the deep and narrow gorges show excellent sections of the veins and the enclosing rocks. It is in such places that the earliest mining was done. The drifts and tunnels driven in the veins disclosed large masses of native copper, carbonates and oxide ores, the existence of which made the region well known throughout Sonora for the last half-century. As the gossan cap is penetrated, the ore beneath is found to consist of pyrite and chalcopyrite, mixed with much earthy and soft black copper-glance.

The ores of the different mines vary considerably in character and value. In general, it may be stated that the ore from the group of mines nearest the smelter, embracing all the bonanza mines of to-day, is quite siliceous, occurring largely in a quartzite gangue or an altered quartz porphyry. The ore from the Puertecitos group is less siliceous, the gangue consisting largely of calcite and garnet. The intermediate mine, the Elisa, has a chalcopyrite ore that is siliceous, but carries, I was told, good values of gold and silver. In the Veta Grande vein large bodies of low-grade ore were encountered carrying native copper in a very siliceous gangue. This ore will average about 2.15 per cent. copper, but also carries about 0.38 oz. gold per ton. It is this ore which can be so easily and advantageously concentrated; tests showing, I was told, a saving of nearly 92 per cent., and the concentrates having 22 per cent. copper and 3.6 oz. gold per ton.

The company now working these mines owns almost the entire district (Fig. 20), and, as a consequence, the development work has been planned and carried out on a broad scale in order to develop the whole tract to the best advantage. In addition to a 42-mile standard-gauge railway-line, built to connect the camp with the El Paso and Southwestern railroad, the com-

pany has built 11 m. of narrow-gauge track, which runs to the mouth of the crosscut working-tunnels driven to tap each ore-body. Well-graded roads, cut out of the solid rock, extend to the sawmill and to the remoter prospects. Pipe-lines convey the water from surface-springs in the heart of the mountains to the city which has sprung up about the smelter, or the newer city on the lower *mesa*. With depth, the mines will undoubtedly yield water, as the Capóte now yields a supply large enough for concentrator and smelter.

The smelting-plant (Fig. 21) embraces six Mitchell Economic Hot-Blast Furnaces, treating over 1000 tons of raw ore per day, and the resulting matte is bessemerized on the spot. The production for 1901 was 34,437,131 lbs., and for the first four months of 1902 was 11,758,072 lbs. of copper and 114,426 oz. of silver.

9. The Sierra Pinitos Mines.

Situation and Topography.

The Sierra Pinitos (Fig. 23) is a range beginning a few miles south of Nogales and extending southward for about 25 miles. It is bounded on the west by the valley of the Rio Alisos (or San Ignacio), a tributary of the Magdalena, and on the east by the valleys of the Santa Cruz and the Cocospera. The peaks of the range attain an altitude of 7400 ft. above sea-level, or 4000 ft. above the valleys. The central and southern portions of the range and its highest peaks are formed of andesitic rocks, while the rougher northern peaks are formed of tuffs and breccias dipping steeply away from the center of the range (the dip lessening on the outer flanks of the old volcano), and resting on the granites as seen near Nogales and the Santa Cruz river. The lower country is heavily grassed, and the uplands and *arroyas* contain magnificent specimens of the various evergreen oaks common in Mexican mountains. The mountains are heavily wooded, oaks prevailing below 5000 ft. and on southern slopes up to the summits, while the high northern exposures are covered by pine (*P. ponderosa*). The topography of the range is clearly that of the normal erosion of a mountain mass (Fig. 22). The drainage is dendritic, and the main peaks lie east of the water-shed.

Geology.—The country between the Alisos river and the

mountains consists of a series of grassy *mesas* with deep gulches between. In Casita cañon and along the streams the rocks exposed are well-jointed, bedded tufaceous dacites of varying color and texture, capped by stream-gravels. The ridges rise gradually toward the mountains, merging into foot-hills. The walls of the lateral cañons show light-gray dacites, but the slopes and terrace summits are mostly covered by large and somewhat angular *débris*. The foothills are composed of the same andesitic rocks and dacite porphyries that form the main peak of the range. The central portion of the range consists of andesitic breccias and tuffs capped by lava flows forming the higher summits. These tuffs vary greatly in appearance, color and texture. Away from the influences of later intrusions of massive andesites and from the mineral veins, the rocks are of earthy brown to green color and resemble the tuffs of the "Fossil forests" of the Yellowstone Park. They consist of large and small fragments of different varieties of andesite held in a matrix of fine particles of dust of the same rock. These rocks are capped by massive red, gray or purple andesites forming the high peaks (Fig. 23) and main divide of the range, while the lesser ridges, particularly near the ore-deposits, consist of a quartz porphyry of distinctly dacitic habit.

Where the streams have cut deeply into the range they have exposed an andesite-porphyry showing white feldspars spangled through a very dark iron-gray ground-mass. This rock varies somewhat in texture and appearance, but is clearly part of a single large intrusion. It has cut through the tuffs in places, but commonly is overlain by them, and has produced a marked contact metamorphism in the latter near the contact. The tuffs seen near Hays's camp are well indurated, as dense as quartzites, lack bedding, and contain fragments of andesite, quartzite, and other altered sedimentary rocks, from 2 ft. across down to the size of a pin-head, none of which are now seen *in situ* in the neighborhood. The rock is so well indurated that the fragments do not weather out in relief. The massive "feldspar-" or andesite-porphyry is cut by dikelets of white aplite. The creek gorges show excellent sections of the andesite, and show it to extend eastward and down the cañons to the granite contact, and always at a lower line than the breccias. The granite forms a distinct area of low foothill country

whose sandy slopes and groups of rounded monoliths are typical of granitic rocks the world over. The rock is a normal, coarse granite, cut by occasional dikes of white aplite and by veins of white quartz. The contact with andesite indicates that the granite is the more recent rock. It forms an oval area of perhaps 2 by 5 miles, whose boundaries are easily distinguished because the coarsely crystalline rock weathers so much more readily than the harder andesites.

Throughout the southern part of the range, which is the mineral-bearing district, the common rock seen on all the ridges and slopes is a pale gray, lavender or white quartz porphyry. The rock is platy, and has the peculiar mottled look of phonolite. As shown by microscopic examination it is a dacite, but not a normal type. Partial analyses showed silica 74.53, soda 3.87 and potash 4.99 per cent. in the rock from the ridge near the Emóle mine. The dacite hanging-wall of the Oro Blanco vein gave silica 73.79, soda 2.2 and potash 5.70 per cent. The exact relation of this rock to the andesitic tuff is obscured by the abundance of *débris* which covers the slopes. At one or two places there is conclusive evidence that it is intrusive; but its general occurrence on the upper part of the ridge indicates that it may be, in part, a series of lava-flows or a single great sheet of massive rock cut through by the streams.

The Ore-Deposits.—The ore-deposits of the Pinitos all occur in the southern part of the range. They consist of quartz-veins carrying gold, and of a wholly different class carrying tetrahedrite and its decomposition-products, with high silver values. Several of the deposits occur on the contact between the common andesitic rock and the intrusive masses of dacite; but the most common is a fissure-vein with a vein-filling of shattered and altered andesite with long, thin lenses of white or rusty quartz (Fig. 24). In the silver-veins the vein is variable in width, with bunches of ore. The extremely fine jointing of the andesite facilitated the passage of mineralizing waters in many small channels, rather than in one trunk-channel, so that the fissure is compound. It is believed that some of the veins in the andesite are nettings of thin streaks of quartz which intersect and form bunches of ore. In general there is a very thin talcy parting along the vein-wall, but the country-rock is altered outside of these walls. No workable veins have been

found in the granite, but they occur alike in massive andesite-porphyry, in the fragmental andesite and the pale-colored dacites.

The veins all have a general N. or NNW. course and are of two sets, one with vertical dip, the other with dip of 40° to 20° E. The gold-veins vary from 5 ft. to 7 ft. in thickness, and carry low values in the altered and pyritized country-rock and high values in the quartz-streaks. The ledges commonly consist of material softer than the enclosing rocks, hence do not show outcrops, save where the quartz-lenses are particularly large and not covered by the dacite *débris*. There is no doubt that the ore will pass into rather coarsely crystallized pyrite in depth, as indicated by pyrite cavities and by nucleal boulders of sulphide ore.

10. The Sierra Azul Mining District.

Situation and Topography.

The Sierra Azul lies between the Cananea and the Pinitos ranges (Fig. 17). It is drained by the Cocospera river, whose broad valley lies west of the mountains. Terraced *mesas* stretch out from the mountains westward, trenched by drainage-ways sunk 50 to 200 ft. below the *mesa*. The mountains consist of a group of peaks without definite order, but having a general north and south trend, and a width of 6 to 8 miles. Beginning in low hills on the north, the peaks rise higher and higher, culminating in a dark wooded summit having an altitude of about 8200 ft. above tide. The drainage is, in the main, radial, but has been influenced by the relative hardness of the different rocks, so that meanders and loops now exist. The cañon walls and slopes are relatively steep, but the high slopes and summits are rounded and smooth, varying, however, with the nature of the rocks. Where granite prevails the contours are gentle, and the slopes, grassy or dotted with groups of oaks, rarely show the grouping of boulders common in granite regions. Good rock exposures are seen in all the creek basins. The streams have a rapid fall, and, though all but devoid of water most of the year, are a succession of rapids and falls in the rainy period, so that the channel is cleared of *débris* and the rocks smoothly polished. There is a marked contrast in scenery between the

grassy slopes of the granite and the jagged pinnacles and cliffs of the indurated andesitic breccia areas.

Geology.—The Sierra Azul consists of a central core of granite, exposed in several separate areas, but believed to be part of one central batholithic mass. Andesitic breccias compose the greater part of the range, as they do in the Pinitos. These rocks are mainly coarse breccias and conglomerates, quite like those of the volcanic mountains of the Yellowstone. Near the granite contact these are well baked, and so indurated that the paste and fragments present equal resistance to weathering or stream erosion, and when broken they fracture without regard to the included masses. The fragments vary up to a foot in size, and include rocks of varying color, appearance and habit. The paste consists of fine particles of the same rocks as the fragments. These breccias occur quite close to the granite, but no actual contact was seen; either there is a lack of exposure or massive andesite intervenes. The breccia is baked by the granite, and, so far as observed, does not contain granite fragments, gneiss, or sedimentary rocks. The massive andesite varies from a porphyritic rock with large tabular feldspars to a dense rock devoid of phenocrysts.

The granite is a coarsely granular hornblende-mica rock of uniform character. It is cut by dikelets of white or pink aplite, and by larger dikes, 10 to 20 feet across, of a dense white rock, a felsite with the texture and appearance of porcelain; these dikes also cut the andesitic rocks. The contacts between the granite and andesite did not afford satisfactory evidence of the relative age of the two rocks, as no actual inclusions of one rock in the other were seen. The andesite at the contact is very dense, while the granite is of normal grain, though so seamed and fractured as to make this uncertain. As slivers of andesite project into the granite, and as the andesites are thoroughly baked and metamorphosed, it seems probable that the granite is younger in age, and has been intruded beneath a mass of andesitic breccias.

Ore-Deposits.—The ore-deposits of the Sierra Azul occur as gold-bearing quartz-veins in granite and silver-copper veins in andesite. The gold-veins have a general NW.–SE. course and dip north at angles of 10 to 40 degrees. The ore seen at all but one working is oxidized, carries fine free gold both in white

quartz and in honeycomb-structured siliceous limonite. The vein-filling consists of crushed granite, with clay streaks and quartz lenses. A footwall streak often shows much manganese, and defines the vein from the hard and blocky granite forming the footwall. This footwall rock shows considerable iron-staining for 3 in. to 6 in. from the vein, but this fades out in a foot or two. A typical cross-section is given in Fig. 25.

The Oro Bonito vein is encased in a white or pinkish granular, aplite granite, sheeted parallel to the vein, and jointed at right angles to it. The quartz which constitutes the pay-ore occurs in lenses a few inches to a couple of feet or more in thickness, separated by crushed vein-matter of altered granite, now a clayey, rotten, reddish or buff material. As these quartz streaks are not persistent, though where one ends the overlapping end of another is usually found, long outcrops do not occur.

At the Esperanza mine the vein passes westward into a barren fissure filled with a breccia of granite and aplite fragments. This appears to be a brecciated aplite dike. The occurrence of the quartz lenses is shown in Figs. 26 and 27. Several of the veins are faulted with downthrows to the north. The unaltered vein-matter contains galena and some copper sulphide.

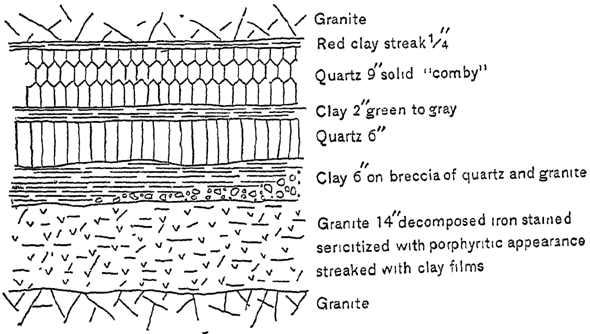
The silver-veins are found in both granite and andesite, though all but one of the veins examined occur in andesite. The veins have regular and well-defined talcy hanging-walls and a rolling footwall. The vein-filling consists of sheared and crushed andesite impregnated with gray copper and a little galena. The Gran Fortuna vein follows the contact between a white andesite porphyry and a dike of chocolate-colored hornblendic andesite-porphyry, both cutting the breccias, and the filling includes streaks of dense quartz and crushed and decomposed andesite with clay films and streaks. The rock of the vein-filling is a tough clay-like mass, devoid in part of ore or quartz, save where secondary carbonates of copper form films in the network of fine cracks traversing both vein-stuff and walls.

The Porvenir vein occurs in a granite containing abundant bunches and aggregates of tourmaline an inch or two across.

The ore-deposit appears to be an attrition breccia, formed by a fault traversing a zone of altered tourmalinized aplitic

granite. The vein averages 5 ft. across, and consists of altered and crushed granite and clay (sericite), in which there are boulders of ore from a few inches up to a foot or more in diameter. These boulders consist of a kernel of black tourmaline, surrounded by a shell, an inch or two thick, of copper carbonate

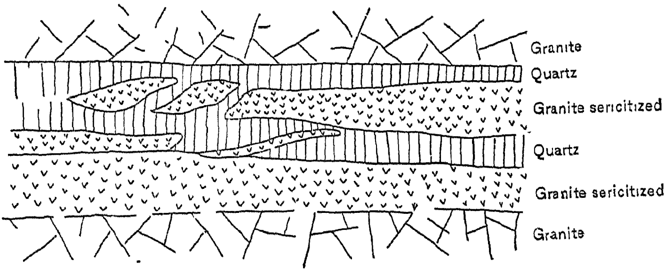
FIG. 26.



Esperanza vein, Sierra Azul.

and silicate. These relations are shown in Fig. 28. The outcrop of the vein consists of a mass of black tourmaline 10 ft. across. Assay of the material free from copper showed 40 cents gold and 1 oz. silver per ton. The bleached sericitized granite forming the vein-filling carries the same amount of

FIG. 27.



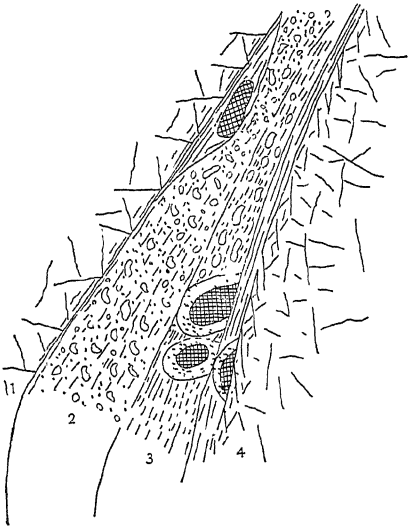
Longitudinal section of quartz-streak, Esperanza tunnel, Sierra Azul.

gold and $2\frac{1}{2}$ oz. of silver per ton. The shell of copper-ore carries $2\frac{1}{2}$ per cent. copper, 11 oz. silver per ton, and 60 cents gold per ton. The vein is believed to be of pneumatolytic origin.

SUMMARY.

The ore-deposits described herein embrace several distinct types. The gold types occur in distinct fissure-veins in andesitic and granitic rocks. From information derived from various mining engineers and from specimens of the ores, the gold-veins of San José de Gracia, and, in general, of the gold-belt northward to the border line, are confined to these andesitic rocks and the granite intrusions in them. The veins are

FIG. 28.



Porvenir Vein.

1. Massive and dense, slightly altered tourmaline-bearing aplite-granite.
2. Breccia of white granite fragments and clay. An attrition, or fault, breccia.
3. Yellow altered soft granite carrying boulders of tourmaline with shells of ore.
4. Crushed granite.

younger than the dacites and rhyolites that compose the Sierra Madre Plateau.

The Santa Eulalia lead-deposits are metasomatic replacements of limestones, partly along fractures and mainly along bedding-planes. They show siliceous concretions and fossils in the ore in the undisturbed original position in which they were in the limestone before replacement.

The copper-deposits are of four classes:

1. In impregnations of upturned porous sandstone strata, resembling the deposits of Corocoro, Bolivia.*

* Lock, "Economic Mining," p. 416, London, 1895.

2. Contact-deposits between a granite intrusion and limestones, a very common type in Mexico. These deposits are not veins, but are due to mineralized vapors and gases given off by the igneous magma reacting upon the limestone walls. They are often characterized by garnetiferous rocks with specular iron. The ores are primarily chalcopyrite, altered to carbonates with the production of gypsum. They occur in large and small masses, and are of irregular and uncertain distribution.

3. The copper-deposits of the Cananea type closely resemble the last. They are tilted beds of sedimentary rock, altered and impregnated with chalcopyrite, and sparingly with galena and blende by contact metamorphic agencies.

4. The copper-deposits of the Porvenir vein, Sierra Azul, Sonora, are closely allied to the contact metamorphic deposits of the two preceding classes, but formed, like the well-known tin-veins of Cornwall, by pneumatolytic action (mineralizing vapors above the critical point and pressure, given off by igneous magma), and deposited in fissures in the consolidated portions of such magma.

The Palmarito silver-deposits are of a type common in Mexico, the vein consisting of a breccia of altered rock, with walls of massive, unbroken rock. The fragments are cemented by quartz carrying silver sulphides and occasionally masses of galena.

The Santa Barbara and Parral deposits are true fissure-veins cutting shales (slates) and the porphyries that break through or overlie them. The presence of fluorite indicates the presence of gases from igneous magmas in the vein-forming waters. (Pneumato-hydatogenetic deposits.)

Notes on a Section Across the Sierra Madre Occidental of Chihuahua and Sinaloa, Mexico.

BY WALTER HARVEY WEED, WASHINGTON, D. C.

(Mexican Meeting, November, 1901.)

THE Republic of Mexico is traversed by many mountain ranges, and presents a great diversity of climates, soils and geographical features, yet its grander geographic provinces are few and peculiarly well defined. The Gulf plain, the Central plateau, the Sierra Madre, and the lowland or Tierra Caliente of the western coast are the main features of the geography of the Republic, and in the northern half these provinces are particularly well defined. The Sierra Madre separates the Republic into eastern and western parts, and from the City of Mexico north to the Texas line presents an almost impassable barrier to east and west travel. On the north, the first wagon-road pass from east to west is at El Paso del Norte, the site of the Texan city of El Paso. Southward for many hundreds of miles the Sierra Madre, traversed by well-worn trails, over which all travel from the west coast to the interior must pass, is a stupendous barrier to social and commercial intercourse.

The Sierra Madre is commonly described as a range or congeries of mountain ranges. In fact, it is, in Chihuahua at least, a great plateau, fringed by mountains on the east, trenched by deep cañons in its center, and bordered by a wild and rugged complex of mountains carved out of the plateau on the west.

Professional duties took me across this region from Parral westward to the Gulf of California *via* Guadalupe y Calvo. As it includes some of the great ore-deposits of Mexico, and its geological features have never, so far as I am aware, been described, I have prepared a diagrammatic section made from my observations on a horseback trip across the Sierra, and added such notes as seem to be of general interest.

The Central Plateau Region.

From the Rio Grande at Presidio del Norte westward to Chihuahua the central plateau presents a broad expanse of rolling, arid tableland, with grass and Spanish bayonet, *sotol*, *yucca* and *cacti*. Detached and usually serrated mountain ranges rise abruptly from this open country. The rocks are mainly limestones, blue, gray or white, and commonly devoid of fossils, though certain beds abound in them. These fossils, wherever seen, were of Cretaceous age; but older rocks have been found by other observers. The rocks are folded in domes as well as the more common synclinal and anticlinal folds, and in places intrusive masses of rhyolite-porphyry and extrusive rhyolite-tuffs occur. Many of the ranges seen along the line of the Mexican Central consist of such rocks, and the silver-mines at Santa Eulalia are in Cretaceous limestones, eroded and partly covered by rhyolite-tuffs. Near Chihuahua the limestones are concealed largely by rhyolite-tuffs of varying texture and color. Southward along the Mexican Central railroad the isolated ranges contain intrusive masses of granite and other coarsely granular rocks, which, breaking through the limestones, are often characterized by contact-deposits of copper-ores; as, for example, those at Jimenez and Mapimí.

The branch line of the Mexican Central Railroad running to Parral and Santa Barbara traverses a plain rising gently westward, and terminating in the hills about Parral, which are outliers of the main Sierra Madre, and are composed of dacite and rhyolite resting upon steeply dipping argillaceous shales, so hard as to be commonly called slates.

The Sierra Madre.

Sierra Madre is a common name on the maps of Mexico, but the only region properly so designated forms the central ridge or backbone of the Republic. It is fittingly named; for it is indeed the mother Sierra, since a great mountain-region has been carved out of it. The elevation west of Parral is about 7000 feet, the summit of the plateau rising gradually to 10,500 feet near the Continental divide, and gradually falling to about 6800 feet, where the plateau breaks into the bordering mass of mountains. As already observed, the Sierra Madre is a pla-

teau, cut by cañons and dissected along its borders. It is built up of successive flows of eruptive lavas, light-colored dacitic and rhyolitic porphyries, the result of great volcanic outbursts and accompanying fissure-eruptions, such as formed the great rhyolitic fields of the western United States. On the east these rocks rest directly upon the folded slates, but on the west upon andesitic and rarely upon granitic rocks. Ore-deposits occur in the fragmental igneous rocks (rhyolites and tuffs) along the eastern border and in similar rocks west of the Sierra; but, so far as my observation goes, the rhyolitic flows of the Sierra Madre proper are later than the ore-deposits, and cover and conceal them. It is only where the underlying andesitic rocks have been revealed by erosion that the mines have been found. In general, these andesitic rocks are of direct volcanic origin, forming an irregular plateau comparable to the range east of the Yellowstone Park, and deeply dissected before the period of the rhyolite eruptions.

Itinerary.

Outfitting at Parral, I took the trail leading direct from the city to the town of Guadalupe y Calvo. A narrow-gauge railroad runs some 20 miles west of Parral; and at the time of my visit, in December, 1900, was being rapidly pushed west of the summit of the mountains. This road will carry great quantities of firewood and mill-material to Parral. Before it was built, all the firewood of the city was packed in on burros. On the first day of my trip at least 1500 burros were passed. A stick of wood as large as one's wrist is worth a cent at Parral; and as this wood has all been packed 20 miles from the mountains, it may readily be seen that the railroad will find considerable traffic in firewood alone.

The country for 5 miles west of Parral shows rough hills, having outcrops of dacite and dacite-tuffs, and intermediate grass-land dotted with bushes. Beyond this broken country there are smooth grass-lands with fine pasture, while the bottom-lands of the river are planted in corn. Distinct outcrops of rock are rare; and the underlying material could only be observed in railroad cuts, where tuffs showed and conglomerates and breccias were also observed. West of this fine pasture-land the foothills show smooth slopes covered with

bushes of scrubby oak, which increase in size as the trail ascends. The first foothills are low, rounding, and show smooth slopes; the rocks are slates whose ready weathering has produced this smooth surface. The slates are much folded, however, and westward, near the pass through the mountains, are covered with rhyolite-tuffs and lava-flows, which form bold pillars, cliffs and peaks. As the altitude increases, pine-trees are observed, and the oaks are no longer mere bushes, but measure from 6 to 15 in. in diameter and 10 to 20 ft. in height. The accompanying diagrammatic section, drawn *en route*, shows the general relations of the rocks. At the close of each day's journey the observed facts were added to the diagram, which therefore represents both my observations and my interpretation of them.

The country between Parral and the crest of the mountains is underlain by dark gray shales and slates. These rocks are folded, but seem to have a general easterly dip. At Parral they are covered by dacitic breccias and tuffs, which form the prominent hills near the city, and are cut by the veins of silver-lead ores which support the industry of that busy town. These rocks all show a widespread decomposition.

The dacitic rocks occurring at Parral are described by Ordoñez* as dark green to dull green rocks, containing scattered crystals of transparent feldspar, together with hornblende, dark green to the naked eye, and *lamellæ* of dark green mica. The magma is in part microfelsitic and in part microlitic, with disseminated particles of yellowish-green hornblende, which gives to the rock its color, and the crystals of hornblende are in part decomposed, and altered, either centrally or peripherally, to calcite, chlorite, or, sometimes, epidote.

Judging by the phenocrysts which it sometimes contains, this rock bears some similarity to the felso-dacites of propylitic appearance, of Rosenbusch, and may correspond in part to the dacites, as well as to the porphyrites, of Fouqué and Levy, which are likewise analogous to some of the propylites described by Zirkel from the Virginia range of Nevada. Here, these rocks sometimes have a lighter color and a more marked porphyritic appearance by reason of an abundance of disseminated feldspar

* *Boletin del Instituto Geologico de Mexico*, Mem. 4, 5 and 6 (1897), 259.

crystals. There also may be observed with the naked eye, and in variable quantity, grains of pyrite disseminated in the paste.

Four miles west of Parral an eroded rhyolite lava-flow was observed, the rock being distinctly vesicular in places, and holding abundant small lithophyses. In the mountains the rocks are mainly tuffs grading into coarse breccias. In general they are dense in texture, and but rarely show phenocrysts of sanidine and quartz. The rocks mainly weather in pale shades of brown, sometimes reddish, often gray. The new railroad-grade, which is largely a rockcut in the steep slopes, shows excellent exposures; this fresher rock being commonly chalk-white, sometimes brick-red. The trail and railroad grade both follow up a clear headwater branch of the Parral river to the low gap in the mountains north of Santa Barbara. From the summit, a chain of bold peaks is seen to the south, while less lofty and rugged heights continue the line northward, and the mountain slopes extend west to a broad plateau.

From the divide westward the trail crosses a basalt flow from 100 to 300 ft. thick, which rests upon the eroded surface of rhyolite. These rocks form an open, grassy basin and rough slopes of very low gradient, bearing scattered oaks. The mesa, standing above the rhyolite-slopes on the west side of the basaltic area, shows that the basalt has suffered some erosion. The basalt itself shows abundant feldspar phenocrysts a half-inch across, with large yellow olivines. The rock varies in texture, but is commonly vesicular and often slaggy in form.

After leaving the basalt, the trail descends a very gentle slope over flows of rhyolite, exhibited as a succession of cliffs with intervening terraces, to a depression in the plateau known as the *Arroyo Hondo.* The country is exactly like the plateau of the Yellowstone Park, save for the oak-groves which dot the hillsides, and look much like the apple-orchards of New England. The rocks are both massive and tufaceous, and appear to be typical rhyolites, showing a ground-mass thickly crowded with sanidine, quartz and biotite. The *Arroyo Hondo* is a deep trench in the plateau, containing the only water for many miles about. West of this *arroyo*, the country is clearly a dissected rhyolite plateau, with rolling surface and an average relief of about 200 ft., embracing a succession of open meadows alternating with low oak-covered hills. Occasionally low ledges

of rhyolite are seen on the more rugged slopes, with occasional bossy outcrops bearing pine-trees which greatly resemble the "long-leaf" pine of the northern Rocky Mountains (*Pinus Ponderosa*). A small species of "two-leafed" pine, resembling the *P. Murrayana* or "lodge-pole pine" of Montana, is also seen.

On this rhyolite plateau, water is relatively scarce; the few streams being shallow, and showing, in the dry season, merely isolated pools of water. Westward, the plateau breaks off suddenly toward the great north and south trench of the Nivarra river. The trail gradually descends the incised front of the plateau which has been cut back by a branch of the Nivarra. The view from the summit, looking west, shows a succession of terraces with what appears to be a high, rough range beyond, having a nearly continuous crest. The aspect is that of a typical rhyolite plateau region. The rocks are mainly massive lavas on the upper part of the plateau, and rest upon tufaceous material in well-defined beds, and composed of various colored fragments in a very pale gray, or light buff matrix. The Nivarra river cuts in the plateau a narrow gulch, 1000 ft. deep, with practically no valley. At the point where the trail crosses it, the river is but a few miles above its junction with the Riparra river, and a branch of the trail follows down the picturesque cañon to the main stream. The trail which we took, however, ascends the steep slopes and crosses a narrow divide about 800 ft. above the stream-level, between the two rivers. The section exposed along the slopes shows that the lower rocks are all dacites and dacitic breccias and conglomerates, the fragments being often but 2 ft. in diameter.

The valley of the Riparra is about 0.5 to 0.75 mile wide, and contains occasional ranches and well-cultivated fields of corn. The bottom is dry and arid, except where cultivated and irrigated. The trail turns abruptly up the valley and follows its eastern margin for about 3 miles, passing the hot springs, which are used for irrigation. The water, at a temperature not exceeding 120° F., oozes from caves in the volcanic tuffs, the water-course and the pool being lined with bright green *algæ*.

According to my barometer-readings, the Riparra valley has an altitude of 5700 ft. West of it the trail ascends to a broad, open, grassy terrace, corresponding in altitude to the

well-marked terrace on the eastern side, the front having an elevation of about 800 ft. above the valley, and the rear being about 400 ft. higher. Looking up the stream, the bedded dacite lava-flows are seen to dip N., or down-stream, while near by and north of the trail the flows have an eastward dip, which probably accounts for the slope of the terrace. This terrace is open and grassy, save where it has been cultivated in extensive corn fields by the Indians of the valley. To the westward, a depression in the terrace is filled with basalt. Across this terrace, which is about 3 miles wide, the trail ascends extremely steep slopes of light-colored dacite porphyries in successive flows. The typical rock is a dense lavender-colored dacite with scanty crystals, and chalk-white to tufaceous in appearance. From the summit (about 8500 ft. high), the trail follows a succession of deeply-incised gulches to the Rosario spring; the rocks being chalk-white volcanic tuffs which weather readily. West of the spring, the slopes ascend gradually to the summit of the plateau, 9200 ft. high. It is evident that the supposed mountains seen west of the Riparra river are in reality merely the rugged and incised front of the plateau. The trail crosses the *arroyo*, an intervening region cut in banded rhyolites, often plated in structure, and follows up a little gulch to another (9200 ft.) summit which seems to mark the general average of the plateau top and then descends about 100 ft. to a basalt-covered area, timbered with fine pines and showing park-like areas containing shallow lakes or *lagunas*. The largest of these, known as the *Laguna Grande*, is a handsome body of water, about ¼ of a mile wide. Several dry basins, observed in the basalt, are believed to mark hollows in the original lava-flow. The summits crossed between the Riparra river and the *lagunas* showed the first good pine-trees seen; and the pine-growth reaches its culmination on the basalt area near the *lagunas*. Here the trees average perhaps 2 ft. in diameter, and many were seen 3 and 4 ft. through at the butt, and over 100 ft. high. The oaks also are larger,—often 2 ft. through, straight in growth, and 30 to 40 ft. high. *Madroñas* and cedars also occur.

The basalt itself is both vesicular and dense in texture, and varies in color from dark steel-gray to chocolate-brown, and shows occasionally glassy feldspars and much iddingsite.

The basalt-area is an ideally beautiful timber-country. The pines are tall and straight, grow relatively far apart, and the intervening space is covered by a fine growth of grass. There are no hills worthy of the name, the average elevation being about 20 or 30 ft. above the *laguna* meadows. This ideal country ends at the *Arroyo de Cuevo Blanco*, where the basalt terminates abruptly, thinning out over the dacite; the latter rock forming great cliffs and huge angular masses, which are not plated, but show great conchoidal fractures, and the lava-flow being exposed in a cliff along both sides of the *arroyo*, and undercut by a small stream, making the cave that gives the place its name. The trail, which passes westward along the grassy bottom of the creek, is much traveled. At the time of my visit, numerous pack-outfits, loaded with oranges from the western slopes of the Sierra Madre, or with merchandise for the interior, together with herds of goats going to Parral, were passed at short intervals.

West of the *Arroyo de Cuevo Blanco*, the trail ascends steep slopes made by the incision of the headwaters of the stream in the main summit of the dacite plateau. The average elevation of the *Laguna Grande* country is 9200 ft., and, according to barometer-measurement, the summit of the plateau west of the *arroyo* has the same altitude. The country is a typical dacite plateau dissected by numerous trenches running N. and S., or approximately transverse to the trail. Westward, the elevation decreases gradually toward the *Rio Verde*. The deepest depression passed is the *Arroyo Muerta*. Here the rocks are bright-red rhyolites, underlying ledges of gray rhyolite breccias, which form the lower part of some 600 ft. of white rhyolite-tuffs. There is a sharp ledge between the *Arroyo Muerta* and the walls of the cañon of the *Rio Verde*. This cañon shows broken walls with numerous projecting points, as the river has a tortuous course and the rocks are soft and readily yield to erosion. The gorge is about 2000 ft. deep, though the actual walls are much less high, as the slope is quite gradual, and it is only near the river that cliffs are seen. The barometer-reading at the river-crossing was 7300 ft. Looking westward across the gorge, the front of the plateau is seen as a black, straight profile, having no resemblance to the mountain-region, although it is commonly called the summit of the Sierra Madre.

The rocks exposed in the gorge are sheeted, the lavender-colored dacites of the lower 500 ft. being overlain by chalk-white tuffs, which extend to the summit. The trail followed up a tributary gulch running at nearly right angles to the cañon and showing walls, 200 ft. high, of rhyolite, eroded in very striking picturesque forms. The resemblance to the Yellowstone Park country is also noted in this little gulch, the rock-outcrops, the spruce and fir timber on the walls, and the willow and the red-bud brush in the stream-bottom furnishing the exact counterparts of similar places in the northern Rocky mountains. The creek also, like the streams in the Yellowstone Park, heads in a shallow depression, on a summit which shows an elevation, according to the barometer, of 9350 ft., while the main summit of the plateau is 150 ft. higher. The rocks encountered appear to be normal Yellowstone rhyolites, varying from an extreme density to a rough texture. Quite rarely, black rhyolite-glass, having the structure of pearlite, is seen. West of the divide the rocks are denser, and often have the structure of porcelain. They occasionally contain spherulites, which are commonly silicified.

Westward, the trail follows for about 3 miles a beautiful willow park, and then crosses rugged hills and intervening gulches to the meadows on the eastern side of the deep depression of Turache creek. It does not descend abruptly into this valley, but follows a stream running SW., cutting through the rhyolite cap, and exposing a bedded basic andesitic breccia. These rocks, indeed, extend to the very top of the plateau; but they have evidently been deeply eroded; since, at numerous places along the stream followed by the trail, rhyolitic or dacitic tuffs are seen resting on the breccias. The altitude of the plateau where the trail begins to descend is 8800 ft., and that of the Turache valley is 6800 ft. The Turache creek joins the real *Rio Verde* 40 m. from the point where the trail crosses.

Beyond Turache the trail ascends the steep slopes of the valley to the summit of the rhyolite plateau. The rocks are massive, with a platy structure. The basalt breccias do not appear west of the range, although the trail follows a steep little gulch, and the rocks are well exposed on the cliffs above. Beyond the Turache ranch and the Guadalupe y Calvo the elevation reaches about 9500 ft. The steep descent to Guadalupe

y Calvo shows good exposures of rhyolite-tuffs of the same character as the rock seen at the town; and the basaltic rocks are not exposed until the town itself is reached.

Guadalupe y Calvo is picturesquely situated in a deep basin surrounded by the steep slopes of the Sierra Madre plateau. This basin is about 1 mile wide and 2 miles long, but there is no bottom-land, the creek cutting a little gorge through the sloping shallow basin-bottom, extending back to the steep slopes. The glaring colors of the place are in marked contrast to the plateau country about it; for the removal of timber and washing away of soil has bared the pink, white, and gray rocks. Seen from the east, the indurated rhyolite-tuffs or breccias form massive exposures, looking like granite, and weathering in picturesque crags, cliffs, etc., which extend continuously along the southern side of the stream past the town. This rock is in turn covered by from 100 to 300 ft. of earthy rhyolite-tuffs, resting upon the unevenly eroded rhyolite, and so soft that they weather readily and form smooth slopes with no rock-exposures. No veins or mines are seen on the south side of the town, where these rocks prevail. On the north, the rhyolite-tuffs are seen to rest upon and cover the veins,—a conclusive evidence that they are more recent than the ore-deposits. Where the rhyolites have been removed by erosion the underlying andesitic rocks are exposed, forming the dull brown slopes seen about the mines. It is evident from the occurrence of this rhyolite that the andesitic rocks were carved into a hilly country, as rugged as that seen to-day, which was completely covered and buried beneath later eruptions of rhyolite as lava-flows and ash-showers. It is evident that these hills sloped SW., down to a lowland; for the andesites do not show south of the town, while the tuffs are piled up to great heights on every side of it. These andesites are bedded, and show, near the Rosario mine, a dip of 80° E., and a strike of N. 70° W. They are mainly of fragmental origin, are well indurated, much altered, and appear to have suffered from contact-metamorphism. They show varying tints, but are thought to be part of a complex similar to that which is seen forming the foundation of the plateau E. of Turache. They are netted with fractures and veinlets of quartz, as well as cut by the great veins of the Rosario, and the group of veins on which the Independencia mine is located.

The town is situated in a little basin cut by the headwaters of Dolores creek in the rhyolite, near the western border of the Sierra Madre plateau. A few miles W. a very rugged, mountainous country begins, the mountains being carved out of the plateau, the summit-level of which their summits approximately reach.

The andesitic rocks are traversed, especially at the E. end of the basin, by a large number of large and small quartz veins. The diagram (Fig. 11)* shows the larger veins only; the intervening areas present small minute quartz-streaks traversing the rocks. The second diagram (Fig. 16),† showing the Rosario outcrop, represents an area where many of the smaller stringers have probably united in the big Rosario vein. The shattered condition of the andesite is well seen, however, in the exposures along the trail cut in the cliffs below the old mine.

A few hours' travel west of Guadalupe y Calvo, the great Sierra Madre plateau suddenly ends, and the sea of mountains formed by the erosion of the western border of the plateau begins. This fringe of mountains, perhaps 15 miles wide, is bordered by rolling foothill country, which gives place to the broad, flat strip of coastal plain extending to the Gulf of California. Isolated mountain ranges occur, however, in both hill and plain tracts, but they trend N. and S., are relatively low, and are not eroded parts of the plateau. The mountain border E. of the Sierra Madre is narrow, and more like a rim about the table-land. On the contrary, the western mountain tract is generally lower than the plateau, is made up of lateral spurs and ridges running transverse to its border, and, in general, shows clearly the branching system due to the dissection of the plateau by the streams. From the Guadalupe y Calvo westward, the andesitic rocks are exposed along the trail to Dolores, but are capped by the rhyolite forming the higher ground. The plateau shows very moderate dissection northward and westward to Baborigame; but the direct trail to La Cumbre goes westward; and as one approaches the plateau edge a V-shaped gap shows a wide stretch of lower mountainous country. The

* Fig. 11 of "Notes on Certain Mines in the States of Chihuahua, Sinaloa and Sonora," by W. H. Weed, page 417 of present volume.

† Fig. 16 of *op. cit.*, page 420.

descent is very abrupt. The trail winds about from side to side of a lateral ridge, and descends fully 1000 ft. in each mile traveled.

At this point the west slope of the plateau is composed of well-banded, highly-indurated basaltic tuffs and breccias, dipping down-stream, 20 to 30° W., and capped with rhyolite flows, not only on the plateau, but on varying lower elevations in the ridge to the west. Evidently the Sierra Madre is made up of a basement of these andesitic rocks, eroded and covered by rhyolite, and the flows have filled up an extremely rugged country. This mountainous tract is the dissected border of the plateau, and bears the same relation to it that the "bad-land" areas do to the flat mesas from which they are derived. These mountains, therefore, show the substructure of the former plateau, and, as their evidence accords well with that afforded by the Turache valley and at Guadalupe y Calvo, it is presumed that the andesites were eroded into very mountainous tracts before the rhyolite eruptions began.

Compared with this western border, in which cuts of 3000 to 5000 ft. prevail, the Rio Verde cañon is shallow. The summit of the plateau is probably 9500 ft. high east, and not less than 7000 ft. high west of Guadalupe. The altitude of the orange-ranches of Rio Domingo is 2900 ft. less. The Rio Domingo has cut down through the andesite breccias to slaty rocks, of which I unfortunately have now no specimens. I do not feel confident that they are not metamorphosed igneous rocks; no quartzite or limestone being observed. The latter rocks are seen only in the main valley of the Rio Domingo; the mountains and small valleys show only the andesites and rhyolite-porphyry caps. Along a branch of the Bazonopa (a branch of the Sinaloa), the river-drift shows boulders of granite and various andesitic rocks, as well as rhyolite.

The abrupt descent from the plateau summit to the Rio Domingo valley is accompanied by a corresponding change in the vegetation. Where the narrow ravines widen and a little strip of alluvium occurs, fields of sugar-cane are found, and orange groves appear. The rank vegetation of the tropics is, however, absent and only suggested along the stream bottoms.

The Bazonopa river, a large branch of the Sinaloa, cuts a horseshoe cañon, some 60 miles long, through the heart of the

western mountain tract, furnishing excellent sections of the rocks. In general, true rhyolitic rocks prevail, forming mountain-summits and cañon-walls. These rocks are plainly seen to consist of nearly horizontal flows, in part of massive lavas, but chiefly of indurated tuffs and ashes, the *ejecta* of old volcanoes, filling deep hollows in the andesitic porphyry. Intrusive masses of granite and diorite also occur, and are shown by included fragments of andesite and their jagged contents to be later in age than the andesites, though older than the tuffs. At La Cumbre, a little mining town nestling in a hollow on the summit of the mountains and sustained by the product of the Guadalupe and Fortuna mines, an opportunity was afforded for a detailed study of the structure and nature of the rocks.

The river gorge is in part cut through all the three varieties of rocks mentioned. The oldest rocks—the andesites—are well bedded, have a prevalent dark-gray or purplish-red color, and vary from coarse breccias, with fragments a foot or more across, to fine tuffs and jasper-like rocks. They appear to be horizontally bedded, and are capped by dacitic rocks. These andesitic rocks form the slope where erosion has removed the rhyolite. They are cut by a granite intrusion on the river-bank; by a larger mass on the summit, at the village of La Cumbre; and by a third mass of granite, three miles farther west. In each instance the andesite tuffs have been somewhat baked and metamorphosed by the heat and vapors of the granite intrusion, so that recrystallization masks the original nature of the andesite porphyry, and gives it a more uniform, almost diabasic texture. Massive andesite-porphyry is also seen below the Guadalupe mine; it has distinct phenocrysts of black augite and white plagioclase, and occurs in blocky masses, forming large, approximately rectangular outcrops, devoid of prominent shooting or jointing.

The granitic rock is a quartz-monzonite, deeply disintegrated, as might be expected in the tropics, so that fresh samples can only be obtained from mine-workings or places where streams keep a fresh surface exposed. In general the rock is deeply decayed, and disintegration boulders occur, mostly small, and showing a pitted or horizontal surface. It apparently shades into a dark basic rock, carrying hornblende crystals an inch

long. The rock is cut by veinlets, and closely resembles the quartz-monzonite of Butte, Montana.

The rhyolitic rocks appear identical with the dacitic, seen farther east. They occur at all elevations, and show plainly that a rugged mountainous district, even more deeply cut than that now existing, was filled up and leveled to a plateau by immense flows of rhyolites and dacitic rocks. The basal beds of this series, as seen near the mine, are at least 1000 ft. thick, and consist of well-bedded tuffs, carrying fragments of rhyolite and boulders of andesite, with distinct alteration-crusts,—one pebble, 4 by 5 in. in size, having an alteration-crust 1 in. thick. The rich gold-veins of La Cumbre are well-defined quartz ledges, cutting andesite and granite, but covered and concealed by the rhyolo-dacitic rocks. In this district the mountain slopes are very steep, averaging nearly 30°, Bazonopa river having an elevation of but 2900 ft., while the mountain-tops vary from 6500 to 7000 ft. West of La Cumbre the route pursued to the coast follows down the deep cut of the *Arroyo Naranja*, the walls of which show bedded andesites, cut by acidic granitic intrusions, which give place farther west to impure, thinly-bedded limestones and shales, with an average dip of 20° NW., and covered by dark-green schistose slates. Granitic intrusions are frequent, and have indurated the slates and altered them to hornstone. The granites, though poorly exposed, are recognizable by the soil. Limestones, which occur in beds from 2 to 6 ft. thick, were carefully searched for, at first without success. They are overlain by basic andesitic breccias, which are also cut by granite intrusions. The granite is a very coarse-grained white rock. The rhyolitic rock still occurs in patches on the higher mountain-summits, but westward, to the plains country, andesitic rocks predominate. In general they are breccias or true conglomerates, with boulders of a foot or so in diameter. They vary greatly in coarseness of grain, and in color they range from dark-red to purple, green and gray. The underlying shales and thinly-bedded limestones are rarely seen in the deeper cuts. No sandstone was seen, but a conglomerate of chert and limestone pebbles, resembling our Dakota group, was seen on the western range of the mountains. These sedimentary rocks are intricately folded, and no general structure could be determined for them. The andesitic covering extends westward to Bacubirito.

The rocks of the Sierra Madre are all so altered by surface-agencies that perfectly fresh material cannot be obtained from natural exposures. Thin sections of the rocks collected on the trip across the Sierra Madre have been examined for me by my friend Prof. Alexander N. Winchell. The prevailing rocks are dacites of varying texture. The ground-mass is commonly felsitic, with phenocrysts of quartz and plagioclase, and rarely orthoclase. In the specimens collected the ferromagnesian minerals are gone; but their former presence is shown by the nests of hematite, magnetite, etc. Spherulitic textures are common in the ground-mass. The most common rocks are dacites, which show crushed and re-cemented crystals of quartz and plagioclase. True tuffs are also very common. These dacites grade into types in which the orthoclase is so abundant as to make basic rhyolites.

The andesites are, as a rule, too badly decomposed for careful study. Those at Guadalupe y Calvo are rather acidic, resembling trachyte in some slides. The rocks on the Bazonopa river are typical augite-andesites, as are also those of the foot-hills W. of the Sierra Madre. The granular rocks on the W. margin of the Sierra plateau are quartz-diorite, later than the andesites and certain of the dacites. This rock shows basic facies at the contact with augite-andesites, the rock being a quartz-olivine gabbro. Quartz-diabase also occurs. Trachytes occur with the andesites, and in the field were not distinguished from the latter.

True granite occurs farther W. at a number of localities. Near La Cumbre the andesites and andesite-porphyry are the oldest rocks; and they are augitic, and sometimes contain large phenocrysts of plagioclase, though commonly they have the nominal andesitic habitus. They are cut by quartz-diorites, covered in turn by dacites, and then by rhyolites.

The order of succession is, therefore:

6. Basalt, the youngest rock of the region.
5. Rhyolite.
4. Dacite.
3. Granite.
2. Trachyte..
1. Andesite, the oldest igneous rock of the region.

The District of Hidalgo del Parral, Mexico, in 1820.

BY NORBERTO DOMINGUEZ, PARRAL, MEXICO.

(Mexican Meeting, November, 1901.)

IN the year 1820 a commission, assisted by Sr. C. Fernando de Ainada, was appointed by Sr. José Ramon Mila de la Roca to report on the condition of the mining region of Parral, in the State of Chihuahua, Mexico, where in recent years the mines of Batopilas have reached an important development under American management. The object of the inquiry was to provide Sr. De la Roca with facts to support a project for reopening mines that two centuries before had produced a large amount of silver. Although this plan failed, many facts of interest in the history of the mines were presented. Much of the report dealt with questions that had only local application or were restricted to the conditions of labor and equipment in the opening of the nineteenth century. The historical part is presented in the following paragraphs:

ABSTRACT OF THE REPORT.

Notwithstanding the difficulty of forming a just estimate of the system of mines in this mineral group in the valley of Senor San José del Parral without an examination of each of them, that which we shall say in a general way will suffice to convey an idea of their value and of the urgent necessity of reopening them. If this is undertaken, we believe the results will be of the highest consequence to the Republic, as well as to this immediate locality.

The group of the Villa del Parral covers the mineral territory in which the village of that name was located. Its mountains contain large metallic veins, from which, as from the trunk of a tree, depend others much more slender, locally called *fibras*, crossing and interlacing each other in many directions. The first and oldest of these very rich deposits of gold

and silver were worked with great diligence by our predecessors, though rudely, because of their lack of experience and the imperfections of their tools. The openings were superficial and confined to the richest parts of the veins. They had less knowledge than we of the art of extracting metals, being ignorant of the use of quicksilver for amalgamation, and of the reagents which these rich ores require. For these reasons the working of the mines fell off, and was at last abandoned until the arrival of better-informed miners, who, by the use of quicksilver, restored the reputation of the mines with a success that is shown by the existence of the village, as well as by the building of works for amalgamation, both hot and cold, and furnaces for smelting and cupellation.

The ease and low cost of working the surface ores led to the hope that mining could be continued in spite of the limited knowledge and extravagant methods of the miners; but they reached the end of their powers, and, perhaps at the same time, the water-level of the mines. The expenses increased with depth, and, though the mines might have been drained, the capital required was not obtainable, as the profits of the mines had been invested in ranches, buildings, and other property, under the impression that their good fortune would last forever. The lack of capital has been the common cause for the lamentable condition in which we see the districts of Santa Barbara, San Francisco del Oro, San Diego de Minas Nuevas, San Patricio, Hueyuquilla, Almaloya, Balcequillo, San Pedro de la Cienega and Ronces Valles. All these mines occupy the best situations. The first five were large producers of gold and silver, but now do not turn out the hundredth part of their former yield, although they contain smelting-ores carrying lead, iron, copper and *magistral.*

The population of this Villa might have been one of the largest in the State, but the stoppage of work and removal of the miners to other localities, like Jesus Maria, has caused the town to fall into ruin. The archives are not full enough to allow us to give a complete account of the history of the mines; and, in their present condition, it is impossible to obtain representative specimens of their ores, as the workings are caved and filled. The archives, which are very voluminous, show that work in the mines of the Villa del Parral began in

1632. Gold-ores had been found and mined in Santa Barbara as early as 1600. The settlement of Santa Barbara took place in 1556, before the discovery of its mineral wealth, and when only Sombrerete, Guadiana and Inde de la Tierrafuera were famous. By the year 1600 it had a population of 7000 miners, and in 1620 there were, in the entire district, 700 water-power *arrastres*, producing from 12 to 14 ounces of gold from a load of 12 *arrobas* (300 lbs.) of ore. In 1632 the deputation of the mines of the Parral and the government of the Villa were incorporated and charged with the duty of keeping the archives. In the same year the authorities of the Santa Barbara mines commissioned Hernando de los Reyes as Inspector of Mines, and from his report we learn that La Negrita, the first mine discovered, was worked by 12 shareholders, and yielded 17 bars from 65½ *varas* (58 yards) length of ground. The San Juan Pedro del Campo yielded 8 bars from 40 *varas* (37 yards). In 1633 a church was built at a cost of 8000 *pesos*. In 1634 the provincial bank was founded by order of the Marquis of Sinaloa in consequence of a report made to him by the Governor, Don Gonzalo Gomez de Cervantes, of the discovery of mines of great richness to be worked by amalgamation and smelting. The value went as high as a mark and a half per quintal (about 12 ounces to 100 lbs.), and many establishments for treating the ore were built. In this year the office of Official Assayer was founded, and Francisco de Zaldaña appointed. In 1635 six deaths occurred in the Negrita mine, which was declared to be badly worked, and thereafter it was operated as an open cut. There were 4 establishments for amalgamation and 20 for smelting. Fifty Spaniards operated the mines in partnership, and others who had found mines were working them in person without any equipment. The town was growing, and the 19 shops which it possessed in 1632 increased to 58 in 1639. In 1645 ores were taken by cart from Parral to Cuencamé, the freight being 7 reals per quintal. The decay of the mines was felt seriously in 1648, the ores being poor and many mines abandoned. More than two-thirds of the miners had gone away. These facts are obtained from a paper which shows that the miners had been paying 800 *pesos* yearly to the support of the clergy, which they were no longer able to do. Between 1641 and 1649, 569,741 marks of silver were

stamped in the office of the Official Assayer. Formerly the miners had enjoyed the privilege of stamping their *cédula* on their silver, which then passed as coin.

From a volume of Acts dated 1648 it appears that the Indians were obliged to work under their *caciques*, but received wages. A census taken in 1649 shows that the mines in Santa Barbara contained only 176 persons of all ages and both sexes, and in San Diego de Minas 72 persons, besides domestics and miners. The old Negrita mine caved in, and the next year (1654) the mines of Santa Cruz were abandoned. From 1641 to 1688, 883,213 marks of silver were stamped in the Assayer's office.

In the latter part of the eighteenth century one enterprising individual worked the mines with such diligence that he is said to have left Parral with a million *pesos*, but he left the mines in a ruined state. Work continued to 1820 in a desultory way. The value of the ore in the mines of Parral was 12 ounces (Av.) to 300 lbs., and anything less than this was not profitable.

Villa del Parral.—The principal mines in this district are those in the hills nearest the Villa. Santa Cruz hill is also notable, because it was thought to contain the mother lode of the district. This lode is on the southern slope of the hill, and runs E. and W. In it are opened the mines called La Ronquilla, El Tajo, Mercaderes, Franqueño, Apodaquena, and Miradeña. On its northern side the hill contains another great lode which crosses from E. to W., and in this are situated the mines called Tecoletes, Aquilareña, Jesus Maria, and La Vivocilla. Both of these were rich and profitable veins, superior to others of the group, and conveniently situated near the town; but the openings in them were limited in extent and made without comprehensive design. The labor and expense increased constantly, and the lack of proper equipment compelled their abandonment when water was reached, leaving riches, greater than they had taken out, to be flooded. The next hill, called Tarahumares, is also near the houses of the Villa, and, in fact, has some dwellings built among the croppings of the great lode that crosses it from E. to W. On that lode was opened the mine called San Antonio. It yielded rich ore, but water was encountered at moderate depth, and the mine was abandoned. The adjacent hills and table-lands of

San Francisco las Cruces contain many veins, in which are the San Francisco las Cruces, Vicheña, Santa Cruz, Chequiña, San José, Jesus Maria, San Vicente, Cabadeña, and Soledad mines. As these are situated in the lowest and most level parts of the district, it is not surprising that water appeared in them at moderate depth, and the mines had a relatively short life.

The great need of the mines in this district is an equipment that will enable them to pump the water and sink shafts to any required depth. All the mines that have been named are paralyzed, not because they are wanting in profitable ores, but for lack of proper machinery. It is well known that the San Juanico mine was the only one supplied even with temporary machinery and worked with vigor. The plant came to the limit of its powers under the management of Don Fernando de Alfaro, and the mine was abandoned. He is reported to have left in the mine ore containing 60 to 70 marks of silver to 12 quintals (800 to 930 ounces per ton), which spurred him to make the greatest efforts to continue the work; but it was impossible, under the conditions.

The mine Cabadeña, discovered in recent times by Clemente Cabada, was worked by him and other poor persons with a success that led to its purchase by men of some resources. They continued the work (putting in an inclined shaft with two whims for hoisting and drainage) as long as they had ore of 4 or 5 marks silver to 12 quintals (52 to 65 ounces per ton), treating it by means of amalgamation. When the flow of water increased, they decided to let the mine fill and make a new perpendicular shaft, which was commenced, but not completed, and the mine remains closed to this day.

In the hills and table-lands situated in the locality called Hormiguero are the mines named Coveña, La Mineria, Santa Clara, Las Gurijas, and that of Nuestra Señora del Rayo. They have been but little worked, although they have produced good paying ores and some with indications of great riches, as shown by the native silver contained in the outcrops. For this reason the miners worked them without leaving pillars, and now they are filled by caving.

The hill adjoining, known as San Blas or de la Palmilla, is noted for the number of lodes running N. and S. within its boundaries, and in them are the San Juan Bautista, La Palmilla,

Santa Gertrudis, La Mortaja, Tarangueña Caldas, Santa Barbara, Nuestra Señora del Carmen, San Rafael, Nuestra Señora del Rosario, San Francisco, La Purisima, La Soledad, La Peña, and Dulces Nombres. The ore is hard and requires good workmen and good tools, as well as the use of powder. The mines of San Blas should be provided with a complete mining equipment. One general installation will be sufficient for all the lodes.

In the hill called de las Vivoras are the mines named La Soledad, San Cristobal, El Carmen, and Palmitas, which are similar in every respect to those in San Blas. They are abandoned for the same lack of sufficient means to continue work in them. After the first miners came the *buscones* (chloriders), who completed the ruin of the mines by removing the pillars, and threw their waste down the stopes, blocking up the good ores below.

In the other hills of the central district of Parral are the veins called del Bellocin, de la Resolana, de los Nopales, La Carniceria, La Roquilla, La Iguana y Teneritos, none of which are of especial importance.

The ores of this central district are very abundant, but the greater part of them yield the small return of 2 ounces of silver to the load of 12 *arrobas* (300 lbs.). This is the general result; but now and then a vein does not give even this return by amalgamation. If it were possible to defray expenses with this yield, mining in the central district of Parral would be on a very extensive scale, and there would be no equal to it in the Republic of Mexico. It would be necessary to remit the taxes upon the silver and provide the mines with the equipment required at cost price. The works needed would not be very complicated, extensive, or costly, in the majority of the mines mentioned, for the mines of Parral enjoy many advantages that the others do not possess. We have seen the ancient mines of Xilotepec and San José de Avenito preserved and kept in constant operation, the first by the help of water-power and the second by animal power. Both defrayed expenses by the proceeds of 2 ounces of silver per 12 *arrobas* of ore. If the district of Parral can be relieved from the tax on silver, and provided with proper machinery, the extensive plant already in place can be made remunerative upon the yield mentioned. At

present, 3 ounces per 12 *arrobas* are needed to cover the cost of the work. Even for ores of this class, carefully planned and permanent works are needed to overcome the ruined condition of the mines. The cost of the work will be abundantly repaid by the plentiful production of silver which is certain to result from the extensive working of the mines.

Santa Barbara.—This mining locality, which is 4 leagues from Parral in a SW. direction, contains both gold- and silver-veins. It is situated among the foothills, and on the eastern slopes of the Sierra Madre. It is the oldest of the mining-camps in the interior States of the Republic, for it was occupied in 1556, when Parral, Chihuahua and other localities were unknown. The first discoveries were made on one of its gold-bearing veins by the old miners, Juan de Velasquez, Miguel de Ituraldi, Venancio de Castro and Bernardo de Santa Ana. The gold-mines of La Vasqueña, Santa Clara, San Francisco, de Pillares, La Antigua, Cinco Toros, Taraciega, Monterilla, Quevadeña, Pelares and Franqueña became famous. These mines yielded ores carrying 12 to 14 ounces (sometimes more) of gold to 12 *arrobas*, and it is said they frequently had leaf- and wire-gold in horizontal and vertical streaks.

The quantity of ore was so great that 700 water-power *arrastres* were kept in operation and supported a population of 7000. The mines were worked to a depth of 150 *varas* (140 yards), and the history of the Villa del Parral was repeated here. No pillars were left to support the walls, and the mining appliances were so poor that on reaching this depth the mines were abandoned, and remain to this day so caved and filled with waste that it is impossible to work them until proper equipment is provided. Many of the inhabitants left when the gold-mines of San Diego de Minas Nuevas were discovered, 2 leagues distant. Those who remained turned their attention to the silver-veins, in which there are now open the mines of Cabrestante, Santa Maria de la Bufa, Ascencion, Nuestra Señora de los Dolores, San José, San Diego, Santisima Trinidad, Dulces Nombres de Maria, La Soledad, San Antonio de Abad, Nuestra Señora Dulces Nombres, San Antonio de Padua, Santa Gertrudis, Las Cabras, Garabatos and Noriegueña.

The silver-mines also were very rich at first, and their ores were treated by smelting and cupellation. Mining was very

active for a time, but soon the discovery of the veins at Parral, and especially those of Chihuahua, drew off a large part of the population. Still, the surplus of lead in the Santa Barbara ore and the supply of litharge from the cupels which was sold at 100 *pesos* per load, was used in beneficiating the dry ores of other localities. This enabled these mines to maintain themselves for many years. There are no other ores of their class in the neighborhood, and the mines of the central district of Parral cannot be reopened with success unless the mines of Santa Barbara are worked also, to supply the necessary lead for the smelting-ores of Parral. This is the only reason for the continuance of work in Santa Barbara, where a small population is still employed in the Ascencion mine. The product of this mine, with the addition of ore sorted from the old heaps, slags from the old furnaces, and the results of prospecting, is sufficient for the small demand in the present condition of Parral.

San Francisco del Oro.—This mining-district is 4 leagues west of Villa del Parral, and also contains veins of gold and silver. It is situated at the base and on the thickly-wooded heights of Santa Barbara in the part facing east. The veins run N. and S., and in the gold-veins are the mines of Santa Barbara, Los Bronces, La Capitaneña, Plaza de Armas, Cinco Señores, La Hundida, La Soledad, Alvaradeña, La Rata, San José de Gracia, Perros Bravos and Arembeña. In the mother lode are the famous silver-mines called San Francisco, Labradeña, Santo Tomas, San Antonio, Sainas, Cuadras, Sabanera and San Rafael.

The first-named gold-mines are in the same condition as those of Santa Barbara, 2 leagues distant, and abandoned like them. It is possible that they are opened in the same veins. The silver-mines in the main vein are rather important, having produced an abundance of paying ore,—sometimes of a very superior quality. Like all the others, they were worked without suitable appliances, and their owners soon found themselves obliged to abandon them while still in good ore. They took out the pillars, and this, with the subsequent operations of *buscones* (chloriders), resulted in the complete ruin of the mines. The San Francisco is the only one which could now be made productive. This is still working to some extent, but

the bottom is flooded by mine-waters. For some time drainage was accomplished by means of a whim placed in the mine, but an accident in the shaft, which resulted fatally to the manager, caused the closing of the work. The ores were treated both by smelting and the *patio*, and the greatest depth reached, according to report, was 200 *varas* (186 yards). The caved condition of the mines forbids an examination, but they contain good ores, and all they need is to be reopened with proper machinery.

San Diego de las Minas Nuevas.—This district is 3 leagues west of Parral, and, according to a registration made in 1645, was discovered by Diego Rodriguez. The mother lode runs N. and S., and yielded ore of excellent quality. Twenty-nine mines were opened on it, some of which were worked to a depth of 200 *varas*. At that depth the mines no longer paid expenses, though the ore improved with depth. The lack of suitable equipment prevented an economical extraction. The high value of the ore led to the robbing of every pillar, and the mines caved in.

The vein is uniformly good throughout,—so much so that it deserves to be compared to the main lode of Catorce or that of Zacatecas. Compared to these mines, which have been worked to a great depth, this may be said to be in its beginning; and, if properly opened, this lode might prove more profitable than those mentioned, which are much exhausted. In support of this statement, it may be added that, though sinking in the district of Minas Nuevas was stopped more than a century ago, the mines have continued to yield, and are still yielding, ore from their upper levels. More than 60 water-power *arrastres* are kept at work producing silver, which is taken to Villa del Parral. The whole body of inhabitants, men, women and children, work in the mines. Much of the ore is sent to Parral for treatment, the supply of ore in the Villa being very scant.

A short time ago, 18 persons formed a company for the purpose of reopening the Franceseña mine by means of a shaft to the drainage-level, but disagreements arose, and the work was abandoned at the depth of 114 *varas*. Afterwards the shaft was denounced by two shareholders, one of whom, Don Augustín Siqueiros, repaired the whim, but did nothing

else, and the work has remained at a standstill. Another whim was placed in a temporary shaft in the old stopes of the Santo Domingo mine. These two undertakings are all that has been done in the last two centuries in these ancient and valuable mines. This district has produced large quantities of easily-worked ore,—so much, in fact, that lead for smelting with it went up to 10 *pesos* per *arroba* (25 lbs.). Amalgamation, both in the *patio* and by heating, has always given good results. The ore obtained in working over the old stopes carries 2 or 3 marks to 12 quintals (27 to 40 ounces per ton).

San Patricio.—This district is about 3 leagues NW. from the Villa del Parral. Its principal vein runs N. and S., and on it the San Patricio, Tares, Trigueros, Santa Clara, Colorado, Moncenate, Campanas, Gomeña, San Francisco and La Plomosa mines have been opened. Like those mentioned above, these mines were very productive and profitable as far down as the mining appliances of that day permitted them to be sunk, and their history was the same, resulting in the robbery of the pillars and the falling in of the mines. After many years, a company composed of 6 persons undertook to revive the San Patricio by sinking a shaft, but the work was done in an ineffectual way, and after various vicissitudes was abandoned. Later on the mine was denounced by two rival parties, who prosecuted their respective claims in the courts of Guadalajara and Mexico for so many years that the timbers of the shaft rotted and caved. A third time the mine was denounced by the first deputy of the district, Don Mariano Deza, who cleaned up the shaft, and was sinking it deeper, when a fire in the store-room spread to the mine and destroyed all the new work. Since then it has lain idle.

Todos Santos.—This district is about 10 leagues N. of Parral, and is situated close to the San Julian Hacienda. As in the other districts, its veins run N. and S. The Nuestra Señora del Rayo, San Francisco Javier, San Diego, Nuestra Señora de la Soledad, San Isidro, San Nicolas, La Santisima Trinidad, San Cayetano, San José de Gracia and Los Dulces Nombres are the titles of its mines. These have been poorly worked, though they have yielded valuable ores. The openings are inferior in length and depth. The ores supply a superior *magistral*, as well as lead and earthy flux. They require smelting,

but the demand for them is now so restricted that there is no encouragement to work the mines. Whenever the mines of the central district of Parral are revived, those of Todos Santos will probably be undertaken also, for the ores of the two districts are complementary in their qualities.

Hueyuquilla.—This district is 20 leagues E. of Parral. The veins in the hills called De los Reyes and Batopilas are N. and S. veins, in which are found the mines named San Nicolas, San Fernando, San Juan, Santo Cristo, Refugio, Santo Domingo, Santa Maria and Magdalena. They are copper-mines, and have been worked but little on account of the small demand for ores of this metal. They are valuable veins, however, and deserve to be compared with those of Santa Clara in Michoacan. The ore is oxide, and whenever copper is needed in the district for replacing worn parts of stamp mortars, or for other purposes, men are sent to mine a quantity of this ore. In this way these mines are valuable to the surrounding districts. Not less important are the iron-lodes of this same locality of Hueyuquilla. They run from E. to W., and are situated back of the hill called Chupaderos. The ore is rich and abundant, and attracted the attention of some enterprising men, but their knowledge was not sufficient to make good use of these fine deposits of iron.

Almaloya.—Nine leagues E. of Parral, and situated in an isolated sierra of the same name, is the district of Almaloya. The few veins that have been found supply a smelting ore. They have been merely prospected by amateurs, who depended upon professional prospectors to do the work, and these did not always treat their employers honestly. For this reason no good commercial results were obtained, and the value of this district is still in doubt.

Balcequillo.—Eight leagues SE. of Parral are hills or tablelands that are called Balcequillo. The veins are only opened by cuts dating from ancient times. The work was prosecuted with vigor, however, for the ores are easily reduced by smelting. The shallow trenches are opened in the decomposed upper part of the veins where the walls are not firm, and they have fallen in. The extent of the mining in Balcequillo is evidenced by the great heaps of slag that remain near the trenches in the outcrops.

In the great reduction-works, called Balcequillo, there had been four furnaces under construction, and two reverberatories, with their necessary adjuncts, all of the best make, and very costly. It was painful to see such a large and complete establishment falling into ruins. The reason for abandoning these mines and works is not known. The district is extensive, and has plenty of ores which are handled easily, and are very useful in connection with those of the other districts. In any revival of mining in this neighborhood these mines should not be neglected. Work ought to be done in the trenches and the veins recovered.

San Pedro de la Cienega.—This district is 7 leagues E. of Parral, lying in the table-lands and hillocks from the *hacienda* of the same name to San Antonio de la Torreon. The veins run E. and W. Nothing is known of the value of the ore, as there are only two openings—the San Pedro and Garniqueña mines, in two parallel veins. Both require drainage. The ores appear valuable, but they were neglected by the ancients, who were unable to extract the silver contents. After lying idle for some time, the mines were declared by the present miner, Don Fernando de Ariada, who equipped them, and succeeded in amalgamating the ore by the *patio* process. At present the returns are 4 to 5 marks per 12 quintals (53 to 66 ounces per ton). Ores of similar tenure are smelted. The depth of the mines is now 60 *varas* vertical. The other mines of Cienega remain deserted, although Don Fernando's skill has shown the possibility of working them with profit.

Ronces Valles.—Five leagues S. of Parral, lying on the eastern slope of the Santa Barbara section of the Sierra Madre, is Ronces Valles. Its veins run N. and S., and the mines are the Sacramento, San Fernando, La Soledad, Santa Gertrudis, San Nicolas and San Camilo, besides many surface openings. The veins have been worked but little, for the ores are poor. Work is kept up in them on account of the *magistral* they yield, which is used in amalgamating the ore of Parral. The extraction of ore is irregular, being confined to the varying wants of the Parral establishments, which send men to Ronces Valles when they need *magistral.* The future of this district is bound up with the reopening of the Parral veins.

In fact, this is the situation of all the ten mineral districts

surrounding the Villa del Parral. The greater number have veins of value, both main and subordinate lodes. A great number of mines have been opened in them, those mentioned here being only the principal ones. All their products are valuable—gold, silver, copper, lead, iron, *magistral* and concentrates.

In addition to the advantages mentioned above is the favorable situation of the mines for establishing the machinery and equipment they need. For the most part the roads are good, and could easily be made serviceable for wagon traffic, and the distances are short. In the small river which flows through the central district there is water enough for the works, though the supply is scant in the summer. The surrounding villages furnish not only mining and living supplies, but men for the mines and reduction-works, and animals for transportation and power. Supplies are abundant and prices reasonable.

The census of the Villa del Parral shows 8000 inhabitants, though the place is largely in a dilapidated condition. The climate is even, and extremes of temperature are rarely felt. The revival of the central district will be the most easy to accomplish. All of these districts, for lack of capital and skill, now produce but little. It is advisable to undertake their rehabilitation without delay, because they are advancing to their complete extermination in a way that will bring the mining industry here to an end in a very short time. The precarious search for ore in the old works must soon he finished, and no fresh discoveries of smaller veins or layers are to be hoped for. The people are too poor to provide the means of draining the mines.

The development of this region has depended, up to this time, upon a mad avarice which sought to seize immediate returns without providing for the needs of the future. The disastrous results have been used as arguments on which to found a distrust of mining enterprises to which the Mexican Republic owes the origin of its agriculture, commerce and arts.

APPENDIX.

Historical and statistical data taken from the programme issued by the Local Committee at Parral for the members of the Institute visiting there during the Mexican Meeting:

Hidalgo del Parral.

"Established in 1600. First records in archives existing in the Town Hall bear date of 1612. The first official register of mines, in the year 1632, is a volume of 485 pages.

"The general formation of the Parral district is porphyry, and the veins are very strong and well-defined. The greatest depth so far attained, despite the age of the camp, is about 1000 feet, and this in but one instance, where the vein not only shows strong, but the values continue about as on the upper levels. The ores of the Parral district immediately surrounding the city are siliceous, carrying a small amount of lead.

"Among the bits of comparatively modern history that are told by the older residents of the place can well be classed as ranking in prominence that of the copper coin 'tlaco.' Early in the 60's of the past century the government of the State of Chihuahua secured authority to issue one million copper coins of the value of three cents each. These coins were called 'quartillos' (a quarter of a real—12½ cents). The contract for the minting of these coins was let to a foreigner, who, realizing his opportunity, minted two million of the coins, floating the extra coin on his own responsibility. Later this was discovered by the State and the value of the coin reduced one-half. The coin was then dubbed 'tlaco' by the poorer classes. It is also interesting to note that in those times all day labor was paid in copper, and many interesting stories are told of laborers who carried home, weekly, from six to ten pounds of copper coin for their week's labor, and even then earning less than one dollar per day.

"*Apropos* of this is a story told of one of the principal business houses at the time taking advantage of the decline of the copper coin. The passage of the bill was anticipated by them and a special messenger stationed at the palace in the city of Chihuahua. The bill was passed on Nov. 9, 1869, and the messenger, riding posthaste, arrived in this city several hours in advance of the government messenger. The house, in the meantime, had invested their surplus copper—about $30,000—in sugar, coffees, and other substantial merchandise, at par.

"It is claimed that Parral was the last town in the northern part of the Republic to surrender to the Diaz authorities in 1876.

"Before the advent of the railroad, ores were hauled by wagon to Jimenez, and from there shipped to Socorro, N. M., El Paso, Texas, or Mapimi, for treatment. With the road came foreign capital; and, seeing the opportunity, heavy investments were made and elaborate development began, with the result that within the past two years mills have been completed (or are now under construction) for the treatment of over 1200 tons of ore daily. Tramways and overhead cables have been put in, and every advantage taken of the natural surroundings, not only for the convenient handling of the ores, but for the reduction of expense, in order that the large bodies of low-grade ores may be advantageously handled.

"*Parral's Railroad Facilities.*—Within the past year the Mexican Central has been extended south-west of Parral to the Rio Florido, a distance of 44 miles. A branch has been built to Santa Barbara, thus opening a new point of shipment for many of the large camps south and west of Parral.

"The Parral and Durango railroad, connecting Minas Nuevas with Parral, and running on west over the mountains a distance of 65 kilometers, taps one of the largest virgin timber belts in this part of the Republic, and if, as intended, it is carried on, will open a valuable mining and agricultural section to the west. A sawmill was recently completed on this line, and square and round mining timber of a very fine quality is now being placed at the different mines at a much less cost than formerly.

"*Mining Camps Supplied by Parral.*—Guanacevi, Inde, Magistral, Guadalupe y Calvo, El Carmen, El Oro, Cordero, Allende, Cusihuarachie, and many smaller camps."

Population of the District of Hidalgo in the Year 1900.

Parral,	16,382
Santa Barbara,	6,714
Minas Nuevas,	5,372
Las Cuevas,	4,788
Balleza,	4,651
Zaragoza,	4,172
Olivas,	2,324
Tuli,	2,533
Rosario,	1,484
Huejotitan,	954
Total,	49,374

Reduction-Works in the Parral District.

	Process.	Daily Capacity. Tons.
Hidalgo Mining Co.'s Mill No 2, . .	Lixiviation.	80
Hidalgo Mining Co.'s Mill No. 3, . .	Lixiviation.	75
Parral Milling Co.'s Mill No. 1, . .	Lixiviation.	50
Parral Milling Co.'s Mill No. 2, . .	Concentrating.	40
F. Stallforth Hmnos., Sucrs y Cia, .	Patio.	40
Angel Garcia (constructing), . . .	Lixiviation.	75

Present Production of the Mines of Parral District (Nov., 1901).

	Description.	Tons, Mill.	Tons, Export.
Quebradillas, ...	Silver.	......	500
Preseña, Alfareña, Morena, ...	Silver.	2500	400
Los Muertos, ...	Silver.	1200	1000
Refugio, ...	Silver.	......	800
Sierra Madre, ...	Silver.	600	......
Santa Ana, ...	Silver.	......	250
Palmilla, ...	Gold.	800	800
Sayñas, ...	Silver.	......	800
Buena Vista, ...	Silver.	......	500
Cerro Colorado, ...	Silver.	500	200
Mary, ...	Silver.	......	......
Jesus Maria, ...	Silver.	800	400
San Patricio, ...	Silver.	500	......
Rebariche, ...	Silver.	200	......
Iguana, ...	Silver.	300	......
Trinidad, ...	Silver.	250	......
Tajo, ...	Silver.	......	800
San Antonio Caldas, . . .	Silver.	200	......
San Cristobal, ...	Silver.	400	......
San Vicenti, ...	Silver.	500	......
La Union, ...	Silver.	1800	......

Minas Nuevas.

"The first mine located (by Diego Rodrigo in 1645) in the district was the Veta Grande, on the Veta Colorado, which is the strongest and most prominent vein in the district, and most probably the largest vein in the Republic of Mexico as to dimensions, and is plainly traceable for a distance of 10 m. over the mountains, averaging, so far as disclosed from present development, about 300 ft. wide. The greatest depth reached on this vein, in the Veta Grande, is about 1000 ft. vertical, or 1250 ft. on the incline; the bottom of the shaft shows a good strong vein, 15 to 18 ft. in width and assaying from 45 to 50 oz.

"Among the older mines on this vein are the San Francisco de la Moreña, worked to a depth of 700 ft. on the incline; the Nopal, worked to 700 ft.; the Preseña and Alfareña, now at a depth of 900 ft. on the incline; Bizcayna, to a depth of about 600 ft.; El Verde, to a depth of about 1100 ft. on the incline. There are also on this vein the Quebradillas, worked on the southern extension to a depth of 550 ft., while the north end, which has been opened in the past ten years, and is now proving a bonanza, is worked to a depth of 725 ft.; Los Muertos, to a depth of 680 ft.; Pachuqueña, to a depth of 700 ft. The ores from the mines located upon this vein carry red oxide of iron, giving them a red color—hence the name 'Veta Colorado,' or Red Vein."

Santa Barbara.

"At one time the capital of the Province of Neuva Viscaya, comprising at that time the States and Territories of Chihuahua, Texas, New Mexico, Arizona, California, and part of Sonora and Coahuila. The first mineral discovered in Northern Mexico was the gold-ore of this place, in the year 1547.

"After a comparatively few years of most vigorous production the mine owners of this immediate district found it impossible to keep miners employed, for at this time the discovery of the famous Veta Colorado was made in the district then known as San Diego de Minas Nuevas—now Minas Nuevas—and a general exodus of miners seems to have taken place. But little mention is made in the records of Santa Barbara after the first flush of discovery had faded until in the early part of the nineteenth century, when mention is made of the advent of foreign capital and of extensive work on the Mina del Agua, which was abandoned after reaching a depth of 60 ft. below the water-level. In the year 1892 it was again opened up; and, with the aid of a very small capital, a foreign enterprise extracted from this mine in less than one year over $80,000, net.

"Mention is made of large and extensive 'gambocino'—gopher—workings on all of the larger veins, which, from general records, have proved profitable to the operator, but most ruinous not only to the mine but to the camp in general.

"The general formation is slate and shale, the trend of the veins being from north to south, the larger and more plainly

traceable of which are the Tecolotes and Mina del Agua, which can be traced for distances of 3 or 4 m. over the mountains, the incline of the veins being from 45° to 75°.

"Near the surface were found pockets of very rich gold-ore; below the oxidized ores, however, the grade is much lower, yet more regular and in large quantities.

"The old method of assaying is most interesting, and goes to show that while the records are exact so far as the primitive method of assaying was able to prove, yet they were no doubt far short of showing the real value of the ores. Three hundred pounds of ore was taken as a sample and treated by the *patio* process, and the silver, after retorting, showed the number of *marcos* per *carga*. Thus the value of the ore was based upon the actual extraction by quicksilver only. In smelting, a similar method was followed, excepting that lead-ores were smelted, and the lead oxidized off, the bar of silver bullion showing the value per *carga*. Many of the slag-piles of smelters that were operated in the olden times have of recent years been bought and shipped to outside smelters, netting the purchasers a handsome profit. Another method of assaying, and that used in many of the more primitively worked mines to the present time, is that of 'blistering' in the blacksmith's forge.

"The allotment of space for appropriate plazas was by no means overlooked by the fathers of the olden time, as the well-regulated plazas of the present will verify.

"About two years ago a California company secured an electric light and telephone concession from the city, and at once erected a modern plant on both systems. About a year ago they extended their telephone system to Santa Barbara, and are now extending to the different mines surrounding the camp. This same company holds a concession for the construction of a water system, active work has been commenced, and it is expected to have the system in operation by February 1st of the coming year (1902).

"The altitude of the city is 5500 ft., making the climate most delightful in summer and mild in winter.

"The Parral river, a small yet permanent stream, affords the city the very best of sewerage outlet.

"Figuring quite nicely in legendry is the church, which still stands in a state of good preservation—that of Nuestra Señora de

Guadalupe—which was completed about the year 1710, being constructed by an Indian who, at that time, was working a gold-mine of fabulous richness, the whereabouts of the same being known to no one but himself, and each Saturday evening he would bring a brick of the yellow metal, with which he would pay the workmen. All efforts of recent date to locate the mine from which the church was built have been unsuccessful.

"In the year 1867 labor-miners were receiving from 50 cents to 75 cents per day; peons, from 25 cents to 37 cents per day. At the present time the former earn from $1.25 to $1.50 per day, and the latter from $1.00 to $1.25 per day.

"The advent of modern steam machinery dates from the early 50's of the past century, when a boiler and engine were put up in the 'Huertas' to operate a large number of *arrastres* and sixteen Castilian furnaces in use at that time. The total output of the sixteen furnaces was about nine tons per day, running at full capacity.

"After this came the *patio* process mill, which is now run with the addition of steam and with the aid of modern machinery.

"The first lixiviation plant in the camp, ruins of which still remain, was erected by the Hidalgo Mining Co., on 'Cerro de la Cruz,' in the year 1886."

Reduction-Works at Santa Barbara.

	Process.	Daily Capacity. Tons.
Montezuma Lead Co.'s Mill, ...	Concentrating.	375
Guggenheim Exploration Co.'s Mill (under construction), ...	Concentrating.	400
San Francisco del Oro, ...	Lixiviation.	40
Parral Mine, Limited, ...	Amal. and Con.	40

Historical Mines.

"Alfareña, San Francisco del Oro, San Albino group, Quebradillas, Los Muertos, Terrenatis, Tecolotes, Mina del Agua, Ceyote group, Franqueña, Veta Grande, El Verde, La Union, Cerro Colorado, Esperia, Hisperides, Caballo, El Toro, Tajo, Prieta, Jesus Maria, Aguilereña, Palmilla, San Juanico, Cabadeña, San Cristobal, San Patricio, Las Cruces, Refugio, Nopal, La Morena, Preseña, Novidad."

The Mineral Zone of Santa Maria del Rio, San Luis Potosí, Mexico.

BY JESUS P. MANZANO, PACHUCA, STATE OF HIDALGO, MEXICO.

(Mexican Meeting, November, 1901.)

THE report of which this paper is a summary was made in 1890 for the Compania Investigadora Mexicana y Americana. Since the region examined covers 900 sq. kilom., chiefly of wooded and rocky hills, almost without roads, and for the most part uninhabited, while the examination had to be made in two months, of which period more than 15 days were continuously rainy, I need not say that this account is not complete and thorough.

I. GEOGRAPHY AND TOPOGRAPHY.

The center of this zone, 19 kilom. SW. of San Luis Potosí, is situated in lat. 21° 24′ N., and long. 2° 3′ W. of Mexico City. The altitude ranges from 1866 m. (that of San Luis) to 2816 m. (that of the Realito mountain), in the Sierra de San Luis. The topography is hilly—partly wooded, partly bare. The principal more level areas are the Bledos valley on the south, and portions of the *haciendas* of Tepetates, San Francisco and Santiago, on the west.

The water-supply is scanty. The two streams that cross the Zone, the Santiago and Bledos rivers, carry water nearly the year through, though much reduced in the dry season. Other streams are torrents of less importance. All the waters of the valley and Sierra of San Luis are absorbed or sink, not passing beyond Soledad de los Ranchos. The Continental divide is within the Zone, some waters going west to the Pacific, others east to the Gulf of Mexico.

II. GEOLOGY.

Concerning the geology of this district I condense the following from the memoir, *Las Minas de Guanajuato*, prepared for the Minister of *Fomento* by Señor Pedro Lopez Monroy, mining engineer, with which I am entirely in accord. He says, in substance:

"The geology of these mountain groups is very monotonous. On every side they exhibit Tertiary strata, in places with the stratification more or less defined, in others with the sedimentary character partially or entirely obliterated, so that the altered rocks occur as trachytic porphyry of varied mineralogical character. On the grand scale these rocks have columnar structure and are precipitous in elevated situations, or at least terraced in bold bluffs, or they may have a stratified structure passing over to well-defined strata. Frequently these strata, altered to porphyry by metamorphism, show locally a spheroidal and spherulitic structure.

"The Cretaceous formation appears upon an exceedingly limited area near the small mining camp of Bernalejo. It is fairly well defined by its lithological characters, being composed for the greater part of well-marked gray *varia*, which alternates with various slates. Although no fossils have been found in these strata, they can probably be assigned to the Cretaceous on stratigraphic grounds, as a continuation of the mountain system E. of the city of San Luis Potosí and of the *Mineral de Pinos*, not far distant.

"Upon these strata, which are covered on one side by the Quaternary of the plain, rest unconformably Tertiary strata that show themselves in the form of boulders of singular aspect.

"The agency that has been powerful enough to alter the pre-existing Tertiary strata to porphyry was undoubtedly basalt and the emanations pertaining to it. It is the only igneous rock that shows on the surface (as on the *Cuchilla de los Fierros*, S. of the *Boca de Cañada*, or in the *Contrapeage;* in *Ojo de Agua, Isidro;* and in *Puerto Colorado* near the culminating point of the high road of San Luis toward the *Villa de Ariaga*, etc.). The metamorphism due to its influence is exhibited clearly in the neighborhood.

"Connected with the basalt are dikes or small eruptions of *vitriofido*, as in the *Cañon de las Presas*, below the *Mesa de la Santissima Virgin*, NW. of the *rancho de Calderos;* S. of and below the *Picacho de Bernalejo;* in the *Mesas de los Chilitos* (southern slope), E. of the peak that stands NW. of *Bledos* and N. of *Carraneo;* in the *Cerro de las Palomas*, W. of Bledos, near the *Mesa de las Ardillas, Pena Larga*, etc. The rock abounds in grains and crystals of olivine.

"It is a notable fact that wherever the *vitriofido* appears, deposits of tin are found near by; so that these dikes may serve as a guide to the discovery of tin-ore.

"The elevation of the mountainous area of the Zone is clearly allied to that of Mexico in general, produced by movements corresponding to a veritable deluge of basalt, most probably of Miocene age.

"Upon the slopes of the mountains of pseudo-porphyry are occasionally found extinguished hydrothermal springs, recognized to-day by the white layers of chalk deposited in short channels; and among these are found skeletons of gigantic mammalia, as at the foot of the *Cerro del Gigante*, NW. of Carraneo.

"In the plains immediately E. of the Zone, which are but the prolongation of the valley itself of the city of San Luis Potosí, should be found, superposed on the Pliocene layers, the heavy Quaternary deposits resulting from the extensive erosions of the mountains produced by rains."

III. Mineral Deposits.

In and near this Zone are found deposits of silver, tin, mercury, bismuth and iron, described separately as follows:

Silver-Ores.

The most important argentiferous area within the Zone is situated on the east in Bernalejo. Silver-bearing veins are found also SE. of San Luis Potosí, toward the *Cañada del Lobo.*

According to information obtained at the last moment, Bernalejo may be regarded as a small mineral district having an extent of about 6 kilom. from N. to S., between Pedernales and Pando hill, and 2 kilom. from E. to W., from the *hacienda Hemsache* to the edge of the mountains. Its system of veins occurs in the slate which, as I have said, is probably Cretaceous; my opinion being deduced from the analogy between this, in which I have not found fossils, and other localities where they have been found.

The strike of the veins varies from N. 40° E. to N. 75° W. (their tendency to change direction being noticeable), and the thickness is 0.20 to 2.35 m. (on the surface; but underground, according to reliable reports, the *Purissima Concepción* mine has reached as much as 6 m.). The dip varies from 68° N. to 67° S. The matrix is quartz and steatite, more or less ferruginous. The unaltered ore consists of gray silver, argentite and ruby silver (pyrargyrite), accompanied by cubic pyrite, chalcopyrite, etc.

I can say nothing about the production and value of these lodes, having had, so far, no results from my inquiries on this subject. The only fact that speaks in favor of their richness is the existence of a considerable production from the *Purissima Concepción* mine. The specimens I have gathered from what was left of the first-class ore do not show a higher quality than 0.02 per cent. (6 oz. per ton).

The *Purissima Concepción*, which belongs to the 3d *Compania Restauradora del Mineral de Bernalejo*, is working now, and has reached a depth of 202 m. Cross-cuts will be run N. and S. to test the principal and adjoining veins, and these will be exploited if ore is found. This company has an establishment, 1.5 kilom. from the mine, containing a Chilean mill, 15 arrastres, an agitator or mixing-tank, and a *patio*. A large smelting-works has been established near the city of San Luis Potosí, and is receiving ores from the various districts of the Republic.

The other argentiferous portion of the Zone is situated, according to information, less than 7 kilom. SE. from San Luis, in the ravine of the Lobo. Various lodes and prospecting-pits are found in this region, which seems inferior to Bernalejo. Want of time prevented my visiting it.

Mercury-Ores.

Only in Zacate hill, N. of *Cuesta Colorado*, have I found cinnabar in semi-opal, but in such small quantities that it has not paid for mining. Trustworthy persons have informed me that mercury occurs in the *Sierra de San Miguelito* also; but I have not been able to find it.

Bismuth-Ores.

At a short distance E. from the *Iglesia del Desierto*, W. of San Luis Potosí, deposits of bismuth-ocher with steatite are found among the deposits of tin. In the same mine, the S. and E. workings produce bismuth-ocher, and the W. workings tin. It has been impossible to examine to the north, because the openings are ruined. The bismuth is found in such small quantities that it has not been worth while to extract it.

Iron-Ores.

Iron-ore is found in various parts of the Zone, but nowhere of valuable quality.

Tin-Ores.

Tin-ores are frequently found in the mountainous parts of the Zone (which cover practically about its whole surface). Both cassiterite and stream-tin are known. The mineral presents itself in several different ways. Sometimes it is in more or less defined veins, in which the ore is now mixed with the matrix, now separated in kidney-shaped pieces, incrustations or nuclei of chalcedony or *cacholonga* (a variety of chalcedony). Sometimes it is found only as seams deposited in the walls by the sublimation of the tin from the interior. It is found also in the conglomerates that fill the hollows of the rocks, and in brooks, or on the slopes of the mountains, in the form of kidney-shaped fragments or earthy deposits, forming at times a kind of placer. Sometimes, again, the tin-ore occurs unaccompanied by other metals; but more frequently it is found with micaceous or red hematite, topaz, etc. There are frequent in-

stances in which the quantity of the specular hematite exceeds that of the tin-ore. When tin-ore is nearly pure, it is called *metal de correa;* when the iron predominates or is equal in quantity to the tin, it is called *plomilla.* The latter requires a more difficult and costly metallurgical treatment, and gives a brittle tin of poor quality—though, with proper treatment, tin of good quality can be made from it.

I have sought carefully for a deposit of tin that would offer favorable conditions for organizing an important industry, and beyond the Zone, southward, toward San Pedro, I have found deposits now actively worked; but these, like all the other deposits I have visited, whether they have been worked and are now exhausted or have not been opened at all, are of very limited dimensions. The largest I have seen is that of *Veta Honda*, in the *hacienda* of San Pedro, worked to a depth of a little more than 40 m. and stoped for a length of 100 m. on a vein which reaches a thickness of 0.42 m. In the *hacienda* of Santiago, the *Rincon Grande* lode, 0.2 m. thick, was opened to a depth of 45 m. and a length of 12 m., producing in the year 1882 more than 44,000 kilog. of tin. I understand that only by fitting up works in a special manner and with extreme economy could there be any profit, and this presupposes a good price for tin.

In the *hacienda* of Bledos, Mr. Yabala, who had been a laborer, devoted himself to exploiting tin-ores, and in a few years acquired a capital of $50,000. The mine of Boquilla in San Pedro, now in operation, with a thickness of between 0.02 and 0.29 m., has produced in its period of abundance 2750 kilog. of ore in a week. Mr. Garcia, who works three mines, was able to establish for about six months a weekly delivery of 400 or 500 kilog. of metallic tin. The tin-ores are variable in yield, the ferruginous kind giving generally 25 and the best from 35 to 80 per cent.

Timber for building and wood for fuel are found only in the southern portion of the Zone, where there is oak, *piñon* or nut pine, *ocote* or pitch pine, and some pine. The forests are not very thick, nor are the trees large. The northern part of the Sierra, toward San Luis Potosí, is absolutely devoid of vegetation. At present the market of San Luis is supplied largely from the United States.

Building-Material.

Calcareous stone more or less good is found in various localities,—not in heavy beds, but in superficial layers of small thickness, covering limited areas. It may be regarded as a calcareous tuff, and is sold in San Luis for $0.50 to $0.60 per 100 kilog. Quartz sand is abundant and sells for little more than the cost of freight, or $0.30 to $0.50 per cubic meter.

Good building-stones are met with everywhere. They are generally porphyritic, more or less resistant, and can be easily cut. I have seen blocks for caps, as much as 5 m. long, used in construction. There is also a pumiceous tufa, lighter and of good resistance.

IV. Means of Communication.

The Zone is situated near four towns: San Luis Potosí, 3 kilom. N. of the N. side; Villa de Reyes, 8 kilom. from the SE. corner; Villa de Arriaga, 14 kilom. from the SW. corner; and Real de Pinos, 40 kilom. from the NW. corner. The roads are in good condition for carts, and the Nacional and Central railroads both pass through San Luis, while the station La Pilla of the Nacional line is within the Zone. In the Zone itself there is only one wagon-road, going SW. from San Luis, which is in good condition on the whole, though somewhat steep in places. The mountainous character of the Zone will make the opening of roads expensive.

V. Labor.

Skilled miners are scarce, but could, of course, be obtained from other parts of the Republic. The laborers of San Luis Potosí are docile, intelligent and industrious. Wages in 1890 were as follows:

A peón received from $0.18 Mex. per day upward.

A driller, $1 Mex. for a hole 84 centim. deep, he furnishing tools and powder.

Or, if working in ore, he might receive $1, $2, or even $3.75 per 11 kilog. In San Luis Potosí the metallic tin is sold at $28 and $30 per quintal.

Blacksmiths received from $0.25 to $0.50; carpenters, from $0.35 to $1.10; and masons, from $0.50 to $0.75 per day—the smaller amounts being paid to helpers and the larger to skilled workmen. The average pay of foremen was $1 per day.

A Study of Amalgamation Methods, Especially the Patio Process, with the Object of Avoiding the Loss of Mercury.

BY MIGUEL BUSTAMENTE, JR., MINING ENGINEER, CITY OF MEXICO.

(Mexican Meeting, November, 1901.)

I. GOLD-AMALGAMATION.

IN 1890 I was manager of a mining enterprise in the State of Michoacan. The ores were composed principally of iron pyrites (much decomposed), in a quartz matrix, with native gold in very irregular grains. Some portions, however, carried their metallic value in a matrix of calcite and siderite. The mill in which the ores were treated consisted of two 800-lb. stamps, two amalgamating-plates, four pans, two automatic washers, two Frue vanners, and the necessary accessories for assaying, retorting and refining gold. The plant, originally erected with American capital, and directed by competent Americans, passed in 1890 into the hands of Mexican owners. On taking charge of the business I found on hand a large amount of ore assaying 35 grammes of gold per metric ton (about 1 oz. Troy per ton of 2000 lbs.); but the company was losing money, and was about to abandon the business.

Obviously, the difficulty lay in the treatment of the ore. The extraction of gold scarcely reached one-tenth of the assay-value; the loss of mercury was considerable; and high freight-charges excluded the alternative of exporting the ores.

This situation naturally suggested that amalgamation was not applicable to these ores, and that a more appropriate method must be adopted.

The cyanide- and chlorination-methods had been tried already, without practically satisfactory results. For the first few months I employed a combined system, extracting a part of the gold by direct amalgamation, and cyaniding the concentrates. This saved 32 per cent. of the assay-value, but the cost of milling still exceeded the proceeds. Meanwhile I observed

that on certain occasions during the amalgamation there was a very perceptible escape of hydrogen sulphide. This I could not satisfactorily explain; but, on the other hand, it accounted for the great loss of mercury which had made amalgamation so expensive and ineffective.

To remedy this (and also diminish the great quantity of cyanide of potassium that had to be used, especially when the gangue of the mineral was calcite), I began with a reverberatory roasting of the crude ore delivered to the mill, and a subsequent washing with water, until the latter came off perfectly clear. The operations of amalgamation, concentration and cyaniding were then performed as before, and the result was a gold-extraction of 63 per cent. of the assay-value, with a loss of 11 per cent. of the mercury used.

This loss surprised me; nevertheless, under these conditions the milling of the ores began to be remunerative, and I could afford to study the subject with more leisure and less anxiety. On further investigation, the gold which had escaped amalgamation was found to be in a peculiar state of aggregation, reminding one strongly of the "platinum sponge" in its tendency to condense some gases. I think that the gold could be found there in another form also, analogous to so-called "black platinum."

Once this fact was discovered, the explanation of the previous phenomena was not difficult. The very finely-divided sponge and black gold, coming into contact with the mercury, provoked an energetic electro-chemical action; and this decomposed a relatively large quantity of water, the oxygen of which was absorbed by the sponge, while the hydrogen, combining with the sulphur of the pyrite, produced hydrogen sulphide. Of the latter, a part escaped as free gas, and a part attacked the mercury, producing mercury sulphide, which explains the great loss of that metal.

Of course the actual reactions are much more complicated than this rough statement; but the principal result, the formation of mercury sulphide, has been conclusively proved by analysis. The loss of the gold is also explained, whenever the sponge or the black gold is present under such conditions as to operate like the electro-positive element of an electric couple; that is to say, when it will receive, condense and hold oxygen,

and be returned by the electro-negative element of the couple in question. This I will prove later on.

The investigation was continued, to find a method of treatment which would both reduce the loss of mercury and increase the extraction of gold. Since the gold occurred in the gangue in grains of varying size, sometimes, but not always, impalpable, it seemed impossible to dispense with amalgamation entirely. On the other hand, a subsequent cyaniding was impaired by the foregoing pulverizing with stamps, which gave a large amount of slimes, through which it was difficult to pass the cyanide solutions. Moreover, these solutions were immediately transformed into carbonates and ammonia salts, and the consumption of cyanide was excessive. Treatment with chlorine was also difficult, and by neither of the two methods was I able, in my laboratory experiments, to obtain more than 40 per cent. of the assay-value.

I resolved, therefore, to continue experimentally the amalgamation, supplemented at first with cyaniding, and prefaced with roasting, as above described. Having abundance of hydraulic power, I began the use, with certain modifications, of the Siemens and Halske method of precipitating the gold. This increased by 15 per cent. of the assay-value the extraction of gold, and also reduced the expense of treatment. Precipitation with zinc was therefore abandoned. The increased extraction was undoubtedly occasioned by the employment of the electric current, since the treatment had not been otherwise modified, and the average composition of the ores had not changed. A comparative experiment, in which a given lot of concentrates was cyanided, and one part was treated with zinc-precipitation, and the other with the electric current instead, entirely confirmed this hypothesis. In the first case 60 per cent., and in the second 66.30 per cent. of the assay-value was obtained.

The examination of various works on electro-metallurgy and electricity furnished me with little or nothing in the way of further guidance, except certain hints as to the movements of bodies and substances in solution, produced by the electric current, and the irregular decomposition of the electrodes, which seemed to indicate the key to the problem. Without recapitulating here the statements of Parret (1816), Becquerel, De la Rive, Wiedemann, Jurgensen (1860), Quincke, Herschel,

and Nobilli, I will simply say that their investigations, together with my own experience, led me to attempt the treatment of the ores in question by amalgamation only, with the aid of the electric current.

Before devising a process of my own, however, I tried those of Body (1894), B. C. Moloy (1894), and others, without satisfactory results. Finally, after some experiment and change in my first apparatus, I perfected a method by which the loss of mercury was reduced to 0.03 per cent., and the extraction of gold brought up to 95 per cent. of the assay-value, while the cost of treatment was lowered until it only amounted to $0.42 per ton for crushing, and $0.19 for amalgamation and the electric current.

At first, this method consisted in reverberatory roasting of the ore and washing abundantly with water, then passing it through the mortars, where it was pulverized and began to amalgamate. The mortars were provided with interior amalgamating-plates, in communication with the poles of a dynamo that produced a current of 150 amperes, 14 volts. The two stamp-batteries discharged into a common channel, in which, side by side, were placed the large amalgamating-plates, one communicating with the positive pole, the other with the negative. This arrangement gave encouraging results; but in view of the energetic decomposition of water which attended it, the electro-motive power was diminished by subdividing the amalgamation-plates and uniting them, not in series, but in tension. This produced the much-desired result. The liberation of gases diminished considerably, and the loss of mercury became insignificant.

Similar dispositions were made for the pans and the washers. Over the wooden shoes were placed amalgamating-plates 2 decim. square, and on the side-walls of the buckets similar plates 0.5 m. square, united, in tension, with the poles of the dynamos, in such a manner that the electro-motive power would not exceed 1.5 volts. Later, the aggregate surface of the plates was enlarged to some 15 m. square, which gave the best results. A further increase of surface would have been useless.

On an average, 9 tons of ore were treated every 24 hours; the extraction of gold was 94 per cent., and the loss of mercury was insignificant.

Still later experiments led to the abandonment of the preliminary roasting of the ore; and this resulted in the maximum gold-extraction of 95 per cent. of the assay-value.

II. The Patio Process.

Subsequently, I had occasion to occupy myself with the treatment of ores by the *patio* process. The ores consisted of a quartz mass, carrying a mixture in variable proportions of miargyrite, polybasite, silver-glance, pyrites, oxides of iron and manganese, and finally some native silver and calcite; zinc-blende was occasionally present.

The plant comprised 50 stamps of 850 lbs.; 30 arrastres; 4 mechanical washers; a *patio* (yard) with a capacity of 1360 tons; and corresponding apparatus, operated by abundant hydraulic power.

All the theories known to me regarding the reactions of the *patio* process are inconsistent with the phenomena observed in practice. As a consequence, the process, empirically, and more or less ignorantly, performed, has often been unfairly discarded by reason of failures due in reality not to its principles, but to its improper application.

Frederick Sonneschmid, who was sent to Mexico by Charles III. of Spain, with the idea of introducing there the German methods of treating silver-ores, did not hesitate to report that the *patio* process was superior to the barrel-amalgamation developed by Born and his successors.*

The theory of Sonneschmid, based upon twelve years of practice in Mexico, may be stated as follows:†

* Sonneschmid's work, *Tratato de Amalgamacion de Nueva España*, was published at Mexico in 1805. A German revised edition appeared at Gotha in 1810; and a Spanish edition (probably translated from the German one) was published by Bossange at Paris in 1825. From a copy of the last edition in the writer's possession the opinion here quoted has been taken. In the *Handbook of Metallurgy*, translated by Prof. Henry Louis from the German of Prof. Carl Schnabel, Baron v. Born is credited with the introduction of the chloridizing roasting of silver-ores at Vienna prior to 1786, in which year the Cazo process of amalgamation in copper vessels, subsequent to such a roasting, was introduced at Schemnitz, Hungary. The later development of the process at Freiberg, Saxony, by the substitution of amalgamation in horizontal, rotating wooden barrels, is ascribed to Gellert and Ruprecht, and it is declared that the first plant on a large scale using the "Freiberg" process was erected in 1790 at the famous Halsbrücker works, at Freiberg.

† This summary is translated in substance from the German of Stölzel's *Metallurgie*, Brunswick, 1886, vol. ii., p. 1232.

Sonneschmid assumed that the *magistral*, in which he regarded the copper sulphate as the chief operative reagent, liberated from the salt hydrochloric acid, which transformed to silver chloride the metallic or sulphuretted silver contained in the ores; and that this silver chloride, in the presence of the excess of salt or hydrochloric acid, was reduced to the metallic state, and amalgamated with part of the mercury, giving up its hydrochloric acid to another part, to form mercury chloride. In addition to the mechanical loss of mercury in the process, there was thus a double chemical loss, due to the formation of mercury chloride, partly by the hydrochloric acid from the silver, and partly by the free hydrochloric acid in the mass.

This theory, as further developed, but not essentially changed, by Karsten, Rammelsberg and Regnault, has been generally adopted. Up to a certain point, it explains the most important phenomena of the process.

The consumption of mercury in this process is generally measured in its proportion to the amount of silver obtained. A loss of 12 oz. of mercury per mark (= 8 oz.) of silver extracted is generally considered good practice; and it is commonly reckoned that of the 12 oz., 8 constitute the chemical loss, and 4 the mechanical. But when docile ores are intelligently and carefully treated, the loss of mercury may be less than 3.25 oz. per 8 oz. of silver—a fact which disproves the theory that the silver chloride is reduced wholly by the mercury; since this loss is much smaller than the chemical equivalent involved in such a reaction.

Experiments made in 1878 at the *Hacienda de Regla*, by my father, Eng'r Miguel Bustamente, showed that when the quantity of salt was augmented, and the treatment was slightly "cold," the total loss of mercury never exceeded 4 oz. per mark of silver extracted.

By another series of experiments, made to ascertain the influence of the impurities of the sulphates of copper employed, he demonstrated that the English sulphate of copper, the purest used in Mexico, did not give as good results as the acid sulphate of copper produced by the Mints in treating gold; and, finally, that the most effective and economical of all is the impure sulphate of copper, with a large quantity of iron, known as "magistral," and obtained by the roasting of chalcopyrite.

These results, repeatedly confirmed by myself and others, likewise contradict the generally admitted principles and theories cited above.

The fact is, that some of the reactions pointed out by theoretical chemists take place; but there are a multitude of other reactions which may and do also occur; and the accessory ingredients of the ore have no less (and probably even more) influence in the *patio* than in other reduction-methods, because the latter may neutralize, by means of appropriate mixture of charges, some of the elements disturbing the desired reaction; whereas in the *patio* no one has taken pains to make such mixtures, but all are content simply to divide the ores into "docile" and "rebellious."

This is not surprising, since the greater number of plants are in the hands of ordinary amalgamating-workmen, ignorant of chemistry and mineralogy, and attached to the routine practice of their fathers. Regular docimastic assays are rarely maintained, and still more rarely used with advantage as checks or guides in daily operations. The assays of the residue are carelessly made, and the treatment is generally guesswork. Nevertheless, the general results in treating "docile" ores are good. If the loss of mercury could always be kept down to 4 oz. per mark of silver obtained, and the extraction of silver and gold up to 95 per cent. of the assay-value, and if this could be done with a larger proportion of the "rebellious" ores, the *patio* would be the ideal method for this country.

Some ten years ago, as a student of metallurgy, I presented, in my examination-thesis, a theory of the *patio* process which I wish now to re-state, without pretending that it solves the whole problem, but believing that it takes account of certain reactions, constantly occurring in the process, which have been overlooked hitherto, though they have a marked influence on the results of the treatment.

The first chemical operation upon "docile" ores is the salting (*ensalmorar*), which consists in the addition of chloride of sodium (from 1.5 to 4 per cent. of the weight of the ore). The salt should be as pure as possible, as its quality has a marked influence on the consumption of sulphate of copper afterwards, and on the pureness of the silver, as well as on the time spent in making up the *torta*.

In the majority of cases I have found the use of an excess of nearly pure salt to result in greater silver-extraction, saving of time in the treatment, and notable diminution of the loss of mercury.

After the mixing (*repaso*), which may be done by peons, horses, rollers, pans, cradles, Archimedean screw, Chilean *alacran*, *arrastres*, etc., comes the "incorporation" of the sulphate of copper, or the *magistral*, and then of the mercury. The quantity of copper sulphate added (varying from 1.5 to 6 per cent. of the weight of the ore) depends upon many circumstances, the principal being the dullness of the workmen and the good or bad quality of the impure sulphate employed. The quantity of mercury added is calculated to be 4 or 5 times the weight of silver expected to be obtained at the end of the operation.

The exact estimate of the quantity of sulphate of copper to be employed is of great importance. If too little is added, the treatment is checked; the sulphate is converted into suboxide of copper; and the mercury, floured and oxidized, cannot be easily recovered by washing the *torta* without some injurious change in the compounds of silver.

If, on the other hand, the sulphate be in excess, the chloride reactions are very energetic, the mercury being rapidly converted into chloride (with liberation of 62.8 cal. of heat); whereas, the formation of silver chloride (liberating only 29.2 cal.) cannot take place. By subsequent reactions and outside influences, among which are the admitted effects of light and organic matter, a portion of the mercury is converted into an oxide, which is, like calomel, almost insoluble in the more or less concentrated solution of salt to which the principal reactions of the *patio* process are ascribed. A considerable loss of mercury is thus caused; and the compounds of silver are so transformed or rendered inert as to hinder their reduction, and produce the indications known to the workmen as those of "hot" treatment.

The addition, as a remedy, of lime, ashes, precipitated copper, etc., cools the *torta*, and destroys the calomel which may have been formed; but it neither reduces the oxidized mercury nor modifies the passivity of the argentiferous compounds.

All the current theories of the *patio* attribute to cupric or

to cuprous chloride the chloridization of the silver in the ore —the copper becoming a sulphide or sulph-antimonide, etc. But many trustworthy laboratory experiments have disproved this proposition. The test is not difficult. Place pure pulverized argentite in a beaker; add cupric chloride in more or less concentrated solution; and the result is *nil*, as could have been foretold from the principles of thermo-chemistry; since the heat of formation of the chloride of silver is only 29.2 cal., while that of cupric chloride is much greater, namely, 71.2 cal. Adding chloride of sodium makes no difference, even after three months. But on the further addition of iron, or metallic zinc in shavings, an almost instantaneous reaction follows; and the more intense the light during the experiment the more energetic will be this reaction. The black silver sulphide is changed to white. This reaction, no doubt, led Kröncke to employ the cuprous chloride in the method which bears his name. When an excess of iron or zinc is added, the energetic reaction rapidly deposits metallic silver—which is not surprising.

This experiment, studied in the light of Berthelot's thermochemical law, confirms the conclusion that the reaction is not a simple chloridization of the silver by the cuprous chloride (the formation heat of the latter being but 29.2, while that of the former is 62.2 cal.), but is in large part due to the metallic iron (or zinc). This conclusion can be further supported by similar experiment, in which cuprous silver is used instead of cupric chloride. The resulting reaction is very slow, and quite insignificant.

On the other hand, the hypothesis of the effective agency of the iron encounters at once the objection that, apart from American pan-amalgamation, the various silver-amalgamation processes do not involve a large consumption of iron; and, moreover, that they produce silver of much higher purity than that obtained in pans, which rarely assays as much as 0.750 fine. It is true that the crushing of ore with modern apparatus exposes it to a certain quantity of iron; that the animals which tramp the *tortas* are shod with iron; but these factors cannot be significant; since, both formerly and to this day, crushing in stone *arrastres* and the trampling of the *torta* by men are performed in remote mining districts of Mexico, with technical results not greatly, if at all, inferior to those of more modern practice.

These objections led me to a series of laboratory experiments which, I think, demonstrate (1) the formation of ferric chloride (Fe_2Cl_6), the formation-heat of which, in solution, is 255.4 cal.; (2) its subsequent reduction to a lower chloride, with liberation of chlorine, which, acting in the nascent state upon the compounds of silver, transforms them into chlorides; (3) the reaction of these chlorides upon the hydrated oxides in the mixture of ore and reagents, and on the metallic iron, resulting in metallic silver with a new formation of chloride of iron, releasing oxygen, and probably affecting a partial regeneration of sulphate of copper; (4) a new formation of chlorides of copper and a continuation of these reactions until the termination of the treatment. This is a *résumé* of my theory of the *patio* process.

What is the *rôle* of the copper in these reactions? Its presence is certainly indispensable. It has always been supposed to play the double *rôle* of the chlorination of the compounds of silver and its own sulphatization. As to the latter reaction: the formation-heat of the sulphate of silver is 3 cal.; that of the sulphate of copper 20.8 cal.; and that of the sulphate of iron, in the most unfavorable case, 41.6 cal. Undoubtedly, therefore, if iron oxide be present, this last reaction will be the one to take place. The state of division of this sulphate of iron; the liberation of oxygen in the formation of perchlorides from the oxides of iron contained in all ores; the humidity; the action of light and of atmospheric agents;—all contribute to the formation of the sulphate of iron, liberating 94.4, and not to that of copper, liberating only 57 cal. This is only an application of the well-known principle of "maximum work."

Continuing: the formation-heat of the chloride of sodium (NaCl) is 58.5; that of sodium sulphide, dissolved, 186.8; that of iron sulphide 94.4; and that of copper sulphide 57 cal. The latter, therefore, will undoubtedly be most easily attacked by the chloride of sodium, since it requires the smallest number of calories to make it resign to the sodium its sulphuric acid, with formation, undoubtedly, of proto-chlorate of copper, which liberates 71.2 cal.

This simple comparison of the formation-heats shows at once the usefulness of the sulphate of copper in the *patio* process,

and also explains the small success of those experimenters who have, in practice, substituted sulphate of iron. The presence of copper is, moreover, of the utmost importance for the preservation of mercury in the metallic state, after the oxides of iron have been transformed into proto-chlorides; the formation-heat of the corrosive sublimate being only 59.6 cal.

It remains to be explained why the "magistral" (*i.e.*, the sulphates of copper and iron obtained by the reverberatory roasting of chalcopyrite) yields, in this process, better results than the English sulphate of copper, chemically the purest in the market. This explanation is very simple, and completes my theory of the *patio* process.

All those who have practiced photography have witnessed the effect of light in reducing the silver-salts and transforming the proto- into the per-salts of iron; also the strong solvent action of iron perchloride upon the salts of silver—especially silver chloride, whether it has or has not been affected by light. The solvent power of iron perchloride upon silver chloride is greatly superior to that of the chloride of sodium, though the latter may be more generally known; and it naturally facilitates and accelerates the reactions in the *patio*. In particular, the chlorination and consequent loss of mercury is diminished, for two reasons: (1) because the quantity of chloride of copper formed is made relatively small; and (2) because the proto- and perchloride of iron immediately formed, instead, from the sulphate of iron of the *magistral*, directly aid in attacking the argentiferous compounds.

The reduction to silver of the dissolved silver chloride may be effected either (1) through the precipitation of silver as an unstable oxide by the oxides of iron naturally existing or artificially formed in the ore, or (2) by the conversion of silver proto-chloride into perchloride, leaving free silver, which amalgamates with the mercury, eluding in this way further chlorination and solution. Consequently, mercury should not be chemically lost in this treatment. In fact, the necessary chemical loss has often been shown in practice to be imaginary. The mechanical loss is the only inevitable one.

The two principal signs observed in the usual tests which have hitherto served, and will doubtless continue to serve as a practical guide in the operation of the *patio* process, confirm part of the theory here presented.

1. The test of a "cold" *torta*, made immediately after the incorporation by trampling, shows mercury, sometimes in part more or less confluent, but usually in small drops, or in the exceedingly fine state of division (floured) which we call *liz*. Rubbing this together, and then attempting to strain it by squeezing, we obtain scarcely any signs of amalgam. The mercury is very white, resembling its natural color, or tending more or less to a yellowish color on the surface, owing (as the experts say) to the formation of sub-oxide of copper. The film of this oxide, covering the surface of the mercury, is undoubtedly due to the decomposition of the chloride of copper by the oxides of iron in the ore; and the quantity of chlorine thus liberated from the copper salt is not sufficient to form the needed amount of perchloride of iron, which, acting in the nascent state, and favored by the heat liberated in its own formation, is the true agent in the chloridization of the silver-compounds. Hence the "coldness" of the *torta*, with the unfavorable conditions which that implies. This phenomenon led me to suspect for the first time the important part played in the *patio* process by the iron oxides and salts of the ore.

2. On the other hand, the *torta* is "hot" when an excess of sulphate of copper has been added. In this case, perchloride of iron is very rapidly formed, and tends to be reduced with similar rapidity to the proto-chloride, converting the mercury to calomel (Hg_2Cl_2), until the reaction provoked by the immoderate use of sulphate of copper has terminated. In this case, practically all the reagents employed are consumed in the chlorination of the mercury, without useful result. The greater part, if not the whole, of the iron oxides in the ores is changed to proto-chloride; and if, after the over-heated *torta* has cooled, pure sulphate of copper be employed to continue the treatment, much difficulty will be experienced in recovering the conditions lost.

Inventors, reasoning upon the reactions of the Freiberg barrel-amalgamation, have proposed the use of metallic iron in the various phases of the *patio* process, as a means of minimizing the loss of mercury. The main result of such a measure has been the requirement of a larger quantity of sulphate of copper, together with delay in the progress of the treatment. The reason is easily seen: the metallic iron precipitates metallic

copper, and this reaction cools the *torta*. The consumption of mercury increases instead of diminishing.

In view of these facts and considerations, it is, in my judgment, the best practice to conduct the treatment of the *torta* moderately and with vigilance, and, upon the least sign of excessive heat, to apply the remedy at once, in the form of a quantity (calculated as exactly as possible) of lime, precipitated copper, or ashes, to forestall the effects of a "hot" *torta* upon the mercury.

As already observed, the proper amount of sulphate of copper required in this process for any particular ore should be as carefully determined, according to the law of chemical equivalents, as the amount and nature of flux required in a smelting process. And it follows that for this process, as for smelting, different ores might be so mixed, after proper analysis of each, as to diminish the necessary amount, or increase the effectiveness of the metallurgical reagents added. Empirical mixtures of "docile" and "rebellious" ores are known to have given excellent results in many Mexican localities; and there is a wide and promising field for the thorough study and systematic application of this practice, which would raise it from the plane of local tradition or happy accident to that of definite purpose and fore-knowledge.

In this, as in other respects, the Mexican amalgamation-process has never had opportunity to exhibit its full technical and economical capacity. I firmly believe that it can successfully compete with smelting, especially in a country like ours, in which, by reason of topographical conditions and the cost of fuel, freights will always be high.

With regard to methods for diminishing the loss of mercury and amalgam, I would here recall the experiments in connection with the amalgamation of gold, described in the first part of this paper. I have similarly employed the electric current in connection with the *patio* process also—not to affect the treatment itself, but to join the metallic particles. The result was, as I had expected, the same as that which had been accomplished with gold. The quantity of silver and mercury recovered was considerably increased; and I succeeded in saving 97 per cent. of the humid-assay value of silver with a loss of only 5.1 per cent of the mercury employed.

The apparatus consisted of a series of amalgamated copper plates connected to the poles of the dynamo, and grouped in tension, so as to obtain, per sq. meter of surface, from one to two volts and 40 amperes of current. These plates were so suspended by means of the canals and inside of the drain of the *patio* in such a manner as to interrupt, to a certain extent, the free passage of the slimes and water, but without seriously hindering or complicating the washing of the *torta*. I am fully conscious that, after more than seven years spent in establishing facts, overcoming difficulties, and perfecting details, my work in the economic utilization of the facts and theories set forth above is, like my attempt to state them here, still far from complete and satisfactory. Nevertheless, this paper, begun two years ago, is now published, in the hope that the suggestions and experiments of others may aid in the improvement and the due recognition of our Mexican *patio* process, so little understood, so often undervalued, and so worthy of a better fame and fate.

The Geographical* and Geological Distribution of the Mineral Deposits of Mexico.

BY JOSÉ G. AGUILERA, MEXICO CITY.

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WITH the imperfect knowledge that we have of the geology of the country in general, and of the numerous mining districts in particular, it is impossible to present an accurate idea of the geographical and geological distribution of the mineral deposits of the Mexican Republic. But, notwithstanding this, it is clear that the deposits are concentrated in limited regions of the country, and that certain deposits are so closely associated as to indicate, beyond doubt, a genetic relationship. The mineral deposits are numerous, and the most of them are found in the western part of the country in a zone following a SE.–NW. direction from Oaxaca to Sonora. In the eastern

* The first part of the original paper, dealing with the Geographical features, has been omitted,—partly for lack of space, and for the further reason that in the Geological portion the geographical location is mentioned in each case.

portion of the Republic are some well-defined deposits extending in an approximately NW.–SE. or N.–S. line.

Geological Distribution.

The distribution of the minerals geographically is the result of the differences of geological structure in the two regions; and it is important for us now to study the relations and dependence of the different deposits and the rocks constituting the surface. The systems of fractures in which the concentration and deposition of minerals has taken place have well-defined relations with the orogenic movements of the country, and, therefore, we may say that, as a consequence, in almost all of the mineral districts of the country there is a fracture-system with a course NW.–SE., which in some cases occurs alone, but in the majority of cases is associated with a NE.–SW. or an E. and W. system; but this does not explain why certain minerals are more abundant in one district than in others. There is, undoubtedly, a genetic reason why ores of different composition should be deposited in fissures, almost contemporaneous, formed in rocks of similar mineralogical composition or showing only trifling differences; and the study of the genesis of mineral deposits, which has scarcely been begun in this country, will furnish an explanation not only of these phenomena of mineralization in contemporaneous fissures, and in rocks of similar chemical and mineralogical character, but also of the constant relation existing between the nature of the rocks and the nature of the deposits. In the meantime, it is wise to continue determining and recording these associations for subsequent investigation as to their origin.

Graphite.—The graphite in the ancient rocks (some referred to the Azoic, and others undoubtedly metamorphic) appears as scales in the mica-schists in the south of Oaxaca and Guerrero, near Jalapa; and in the metamorphic rocks of Molango, district of Jacala, Hidalgo. In pre-Cretaceous eruptive rocks, it is found in the granulite of Ceuta, near Tixtlalcingo, and of Jalapa, district of Allende, Guerrero; also near Molango. At San Juan Coatecas Altas, district of Ejutla, Oaxaca, it occurs in small veins of granite and granulite. It also occurs in small quantities in the post-Cretaceous diorites (in all probability Eocene) of the Campana hill, near Hermosillo. In the Upper

Triassic of Sonora it is found in many places in the Yaqui and Matape valleys as a metamorphic graphite formed from coal. It is more abundant and of a better quality in the districts of Hermosillo and Ures.

Stone-Coal.—This is found in the Upper Triassic of Sonora, and in deposits of the same age in the south of Puebla and northern Oaxaca; in the Upper Cretaceous of Chihuahua and Coahuila; in Eocene sedimentary deposits near Laredo and Guerrero; in Tamaulipas, and in the Miocene near Mier.

Hydrocarbons.—These deposits occur in formations ranging from the Upper Cretaceous to the Pliocene, along the coast of the Gulf of Mexico, from Tamaulipas to Tabasco. They consist of petroleum, grahamite and bitumen, the solids being formed by oxidation of liquid hydrocarbons. Petroleum is also found in Oaxaca on the Pacific coast, but we have no data concerning the geology of this region, in which granite, granulites and pegmatites appear to predominate.

Opal.—Opal is found in the rhyolites of the early Pliocene, in crevices and in fractures of contraction made while the rock was cooling, and filling small cavities and geodes.

The principal deposits are in the States of Querêtaro, San Luis Potosí, Hidalgo, Michoacán, Chihuahua and Guanajuato. The opal is formed by the circulation of hot waters, which deposit the hydrated silica in all the openings and passages through the rock-mass. Hyalite is very common in the Tertiary eruptive rocks, in the acidic as well as in those that are neutral or basic. Menilite occurs as concretions in the travertines deposited by hot springs.

Asbestos.—This mineral is found in the mica-schists in southern Puebla and northern Oaxaca and Guerrero. It occurs in thin irregular veins with great variations in quality, the fine fibrous asbestos being extremely scarce. In the same formation are veinlets and threads of chrysotile or fibrous serpentine, which occur as a modification in the structure of the serpentine encountered in this region, and which, like the asbestos, appear to result from the alteration of the greenstones (hornblende-granite, granulite and diorite), as well as from the alteration layers of amphibolite intercalated between gneiss and mica-schists and of actinolite-veinlets existing in the region of the mica-schists and gneiss.

Topaz.—This mineral is found in the Pliocene rhyolites of San Luis, Guanajuato and Durango, and generally accompanies the tin minerals. At Cerro Mercado, Durango, however, topaz is associated with iron-ores. The topaz, like the tin and its accompanying wolfram, is found only in the rhyolite of the central part of the country, where this rock occurs in volcanic chimneys. It is not found in the rhyolites of the northern part of Mexico, which came through large fractures and spread over the more ancient eruptive rocks; in these at this writing we know of no tin-veins, and naturally, therefore, no topaz.

Beryl.—Beryl has been found in the mica-schists near Tejupilco, but not in tin-veins, as it is in Saxony and Bohemia, nor in granulite,* in which, in other countries, it is frequently present in small hexagonal crystals as an original constituent of the rock.

Garnet.—Garnet occurs in the mica-schists in the south of Puebla, northern part of Oaxaca and Guerrero, and the Altar district, Sonora, and in the granites that cut through the schists. It also occurs as a contact metamorphic mineral in the copper-deposits of the Cretaceous limestones, which are seen at the contact between the limestone and the diorites, granites, etc., in the mines of San José, Tamaulipas; Pánuco, near the city of Romero Rubio, Coahuila; San Juan de los Llanos, Hacienda de la Cofradía, Puebla; the Encarnación mines, Hidalgo; San José, near Zimapán; Cerro del Sacrificio, Partido de Nombre de Dios, Durango; Asientos mines, Aguascalientes; mines of Cacoma, Jalisco; Rey and Reina mines, Jalisco; Hornillas mines, Mapimí, Durango; San Juan de Guadalupe, Durango; Velardeña mines, Cuencamê, Durango; Sierra del Carrizal, Nuevo León; Concepción del Oro mines, Mazapil, Zacatecas; Sierra de Baoz, Rio Florido, Chihuahua, and the Magistral mines, Chihuahua.

Garnet is found in metamorphosed Cretaceous limestones along diorite dikes, and in the proximity of gold- and silver-bearing deposits of iron-ore. Among these deposits may be mentioned those in the hills near Xalostoc, Sierra de Tlaica, Morelos; Peras mines, Villa Alvarez district, Oaxaca; the

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* The author uses this word in the French sense, to denote a siliceous granite, or aplite, and not the variety of metamorphic schist so-called by German geologists.—SECRETARY.

Municipality of Zapotitlán, Tehuacán, Puebla; near Lake Jaco, Chihuahua; Peñoles mines, Durango; Sultepec mines, State of Mexico; Municipality of Ayala, Morelos; and the mines of Guadalcázar, San Luis Potosí. Garnet is also found in labradorite in the hills of San Cristóbal, Pachuca, Hidalgo.

Sulphur.—Sulphur is found in the solfataras of Popocatepetl, Ixtacihuatl, Citlaltepec and the active volcano of Colima; at the hill of Col near Guadalajara, and in the Tajimaroa volcanoes. Also, in very small quantities, in the Tertiary marls, probably at the base of the Pliocene, near Chila el Grande; in the sedimentary gypsum-deposits, probably of late Eocene age, at Huamuxtitlan, Guerrero, and Silacayoapan, Juxtlahuaca, Oaxaca, in very small amounts. In the Cretaceous limestones of Mapimí, Durango, it is intimately related to the eruptive rocks, and owes its origin to hot waters circulating in and dissolving the limestone, and forming cavities which are filled with sulphate of calcium; this is reduced by the organic remains in the limestone, and the result is the deposition of sulphur. It is also found in mercury- and antimony-veins in Cretaceous limestone, as, for example, at Guadalcázar, Hacienda de Bocas, Sierras de Catorce and Charcas, San Luis Potosí, and near Huitzuco, Guerrero, originating both from the reduction of calcium sulphate (gypsum), and from the decomposition and reduction of the antimony sulphides. Notwithstanding that the deposits are in Cretaceous limestones, they are of a more recent age and almost all of them are related to the eruptive rhyolites; we must therefore concede that the deposits are, in all probability, of middle Pliocene age.

Selenium.—Selenium and its various compounds occur in argentiferous veins in the hornblende-andesite of the Sierra de Guanajuato.

Tellurium.—The only known ore is the telluride of silver, hessite, found in some of the mines of Jalisco and Tepic, the veins of which are in Tertiary andesitic rocks.

Fluorine.—Fluorite is not found in the gangue of the tin-veins of Mexico, as is frequently the case in tin-deposits in the white mica-granite of other countries; this constitutes a difference between those veins and ours, which are always in rhyolites, but never in granite or granulite. This mineral is very rare and is regarded as a real curiosity in silver-veins; those

in which it does occur, like the veins of Cuchara, etc., and of Zacualpan, are rich in galena. It is found in the Madre vein, Guanajuato, but in small amounts. The lead-veins of the Cretaceous limestones very frequently, almost constantly, contain fluorite and barite together. The association of barite and fluorite in the lead-veins is analogous to that in the Triassic deposits of Central Europe.

Salt.—Saline springs are found flowing from the Lower Cretaceous slates in Tehuacán; in the mica-schists of the districts of Chiautla and Acatlán, Puebla, and of the district of Huajuapan, Oaxaca; in the marls and gravels of the Upper Cretaceous of Coahuila, and in the Tertiary in some parts of Tamaulipas.

Barium.—Barite occurs in veins in the tourmaliniferous granites of Lower California, but at this writing we have not sufficient data to determine their age. On account of the chemical and mineralogical relations of barium and lead, which are more intimate than those which exist between barium and calcium, which are generally associated, it is very constantly found as a gangue associated with calcite in the lead-veins. Its presence is accidental in copper-ores, and it is very rarely found in silver-deposits; it is more frequent in lead and copper-silver deposits. As a proof of their chemical and mineralogical similarity we may mention the isomorphism of the sulphates, barite and anglesite, and of the carbonates, witherite and cerussite. Barite is found as a gangue in some of the copper-deposits in mica-schist and gneiss, containing chalcocite, chalcopyrite and blende, and, in the oxide zone, carrying oxides and carbonates of copper.

Strontium.—The only known deposits of celestite are in the slates and gravels of the Upper Jurassic and in the Lower Cretaceous limestones on the eastern slopes of the Sierra de Catorce. These are intimately mixed with small veins of porphyry. The matrix of the celestite deposits is calcite, without the anhydrite, gypsum or quartz, with which celestite occurs in the veins at Condorcet, France.

Kaolin.—The majority of the kaolin-deposits in Mexico, known at this date, originated from the decomposition of the rhyolites; such are the deposits at Zacualtipán, Hidalgo; Rancho de Morga, Durango; and San Ildefonso, district of Tula,

Hidalgo. The Santa María Coayuca deposit, near Chignahuapán, Puebla, is probably of the same origin.

These kaolin-deposits are of a different age (Tertiary) from those of Europe, the latter being older, and derived from the decomposition of granulites. Foreign kaolins are associated with tin-veins; and this is also found to be true in Mexico, since our tin-veins are found in rhyolites and modern acid rocks, of which, as has been said, our kaolin is the decomposition-product. It is a curious fact that the deposits of kaolin in Mexico which have been mentioned lack fluorine, the mineralizing agent of the veins in granulite; the presence of fluorine is recognized in the tin-veins only by the existence of topaz, which occasionally accompanies the cassiterite.

There are kaolin-deposits in the immediate vicinity of the villages of Teopantlán and Ahuatlán, in the quartz-gravels of the Upper Triassic. In the same class of deposits in Sonora the kaolin is in irregular beds, near the base of the strata, and at some places below and almost in contact with metamorphosed anthracite. This kaolin seems to be due to the decomposition of the old granulite, above which rest the Triassic sediments. The granulites in Sonora cover a considerable area and show a well-marked metamorphic character; the subdivisions of the mass, in very regular heavy benches, give the rock a sedimentary aspect.

Iron.—In the south of Puebla iron-ore occurs in lenticular intercalations in gneiss and mica-schists, and consists of compact hematite with a small proportion of magnetite. Stratified deposits of hematite, occasionally accompanied by small amounts of siderite in the center of the hematite nodules, form workable beds in the Upper Triassic deposits of Sonora, the southern part of Puebla, and the northern part of Oaxaca, where the deposits are more regular than in Puebla. Hematite occurs in the northern part of Guerrero, between Olinalá and Chilapa, in veins which cut the mica-schists. For lack of data the precise age of these deposits has not been determined, but they are probably Tertiary, for in the immediate vicinity of Chilapa the veins cut the Cretaceous limestones.

Contact deposits are very abundant, the ore being a compact hematite containing some magnetite, and sometimes accompanied by pyrrhotite. These deposits are seen at the contact

between the Cretaceous limestones and the diorites, quartz-diorites and micro-granulites, or in the zone close to the contact, in which contact copper-deposits are frequently present. As an example, we may mention Cerro Mercado in Monclova, Coahuila. As an example of hematite-veins in contact with quartz-diorite, we may mention those of San José, Sierra de San Carlos, Tamaulipas. The veins of Encarnación, Zimapán, Hidalgo, are also in the contact of limestone and quartz-diorite, and are intimately bound with diorite; the Xalostoc veins, Morelos, are near the contact of limestone with micro-granulite (?); those of Tlaxiaco, Oaxaca, are in the contact of diorite dikes and the Cretaceous formation; the deposit of Rancho de Ayuquila, Puebla, are of hematite, and appear to be genetically related to the hornblende-andesite, since no diorite has been found in the immediate vicinity of the veins. The hematite veins which cut the Lower Cretaceous rocks at Ranchos del Espinal and Platanar, district of Temascaltepec, have a course NE.–SW., the same as the silver-veins of the district, and appear to be dependent upon the andesites of the region. These deposits of iron are analogous to those of the Banat, Hungary and Servia, and appear, like those, to belong to the transition period between the Miocene and Eocene. Probably the iron-deposits we are considering are of Eocene age, and perhaps some belong to the base of the Miocene. These deposits resemble those of Hungary, Servia and the Banat, in that the matrix is garnetiferous, and some of our veins show copper minerals mixed with hematite. They also have some analogy with the iron-deposits of Nijni-Tagil, the only difference being in the age of the limestones and diorites; in Mexico the former are Cretaceous and the latter Eocene, while in all probability both rocks at Nijni-Tagil are Paleozoic. Like the deposits of the Ural, most of the Mexican deposits are associated with copper-deposits, in close proximity, in which copper has been concentrated by secondary reactions, producing a separation of the two metals, which perhaps may still be associated in depth, and whose separation was due to a solution of the chalcopyrite and a deposition of the copper under the influence of the limestone.

Hematite accompanied by magnetite forms veins in the Pliocene rhyolites, and at Cerro Mercado, Durango, it is ac-

companied by apatite and topaz. Hematite accompanies cassiterite in the tin-veins in rhyolite; and, finally, specular hematite is frequently found in the crevices and recesses of the andesitic rocks and granites.

Manganese.—Manganese, which, in nature, is as widely distributed as iron, though in less quantity, is generally associated with iron, and this association is so constant that there is scarcely any iron-deposit that does not contain manganese in greater or less quantity. However, in Mexico this association is not manifest, and scarcely any of the iron-deposits contain manganese; on the other hand, veins containing manganese only are not rare, as is the case in other countries. Veins of pyrolusite, psilomelane and wad are found in the Cretaceous limestones in the districts of Acatlán and Tepexi, in the southern part of Puebla. Irregular veins of psilomelane are known in the Cretaceous limestones in Sierrita de Metoche, near Coxcatlán, Guerrero. Manganese sulphide, alabandite, accompanies the silver-lead minerals of Sierrita de Tepeyahualco, Puebla. The silicate and the oxides accompany the minerals of some of the silver-veins; the former being found in the zone below the hydrostatic level; the latter in the upper oxidized zone; in passing from the silicates to the oxides, the carbonate, rhodochrosite, is found in the intermediate zone. As examples we may cite the veins of Pachuca and Real del Monte, Hidalgo, and the deposits of Tetela del Oro, Puebla.

Chromium.—Chromite is only known to come from two localities in Puebla,—one being the district of Atlíxco, near Matamoros, where it appears in veins cutting the Cretaceous limestone near its contact with the Tertiary eruptive rocks; the other is near Chinantla, in veins which cut the mica-schist. These veins appear to be related to the andesites of the locality; but in neither of these two places is there any certain knowledge that peridotites or serpentines exist, in which rocks chromium is found in other countries; nor is it accompanied by opal, although chrysolite is found in some places near the chromite deposits of Chinantla, but not in the same veins.

Nickel.—Nickel, like chromium, is very scarce in Mexico, and it has only been found as an oxide or arsenide associated with iron in veins of Tertiary age, which cut the Cretaceous limestones in the Tolimân district, Querétaro; these veins

are rich, yielding $9\frac{1}{2}$ per cent. nickel, and are associated with specular iron-ore. The pyrrhotites, which in other countries contain variable amounts of nickel, appear to be destitute of nickel in Mexico; for none that have been analyzed contain any nickel.

Vanadium.—The mineral cuprodescloizite (or ramarite) forms veins at Charcas and Catorce; in the first-named place it is argentiferous. At Pozos, this mineral occurs in the Santa Brígida vein associated with the silver minerals. In Charcas, as well as Catorce and Pozos, the veins cut the middle Cretaceous limestones and shales, and are considered as belonging to the Tertiary age. According to the best information, vanadium was first discovered in Mexico by Del Rio in the lead-bearing veins of Zimapán, which are of Tertiary age in Cretaceous limestones.

Tin.—The tin-deposits of Mexico are of two classes: Those of the Tertiary, and the alluvial placers of the Quaternary. The tin-veins of Europe are always directly related to or associated with granulite, in which the tin is frequently found as an impregnation, and the workable veins are in the contact of the crystalline schists and granulite. In the United States tin-deposits are found in crystalline rocks associated with greisen. The rocks of the Black Hills, South Dakota, in which tin has been found, are of Algonkian age. In Europe and the United States the older tin-veins show an association of minerals as characteristic as the association of the veins with the enclosing rocks,—the minerals containing combinations of boron, fluorine, tungsten, niobium, tantalum and other rare elements, while the enclosing granitic rocks and crystalline schists contain a lithium-mica. In Mexico the characteristic association of minerals and rocks is, so we might say, that of the latest tin-veins of the Tertiary, in which are found crystallized hematite, topaz, and in some cases wolframite and durangite. The associated rocks are Pliocene rhyolites and rhyolitic tufa.

The tin-veins of Mexico must be considered the most recent of all the Tertiary tin-deposits, since those of Tuscany and the Island of Elba are related to eruptive granulites, and those of Bolivia are in andesites or trachytes (?) carrying cassiterite together with sulphides of lead, copper, iron, silver, bismuth and zinc, but lacking tourmaline, topaz, apatite and fluorite.

In San Luis Potosí bismuth is found in the tin-veins in such a manner that in some parts they are rich in tin, in others rich in bismuth. The largest vein is only 0.40 meter in width, and has been worked to a depth of only 40 meters. In this vein the tin is always accompanied by crystallized hematite and some topaz. The veins commonly have an E.–W. course. In the Sierras de San Francisco, Potrillos and Jaco, in Durango, the cassiterite is in small contraction-fissures made by the cooling of the rhyolites and rhyolitic tufa, and is accompanied by wolframite, durangite and topaz. In none of the tin-veins have we any knowledge of tourmaline being found.

Tin-veins in rhyolite and rhyolitic tufa are found in the States of Hidalgo, Jalisco, Nuevo León, Puebla, Querétaro, Durango, Guanajuato, San Luis Potosí and Zacatecas, being more abundant in the last four.

Placer-deposits occur in the same States in the immediate vicinity of the veins, and are the ones that have generally been worked. They are rich and easy to work, as the mineral in the course of time has been concentrated by the streams of water.

Bismuth.—Besides the presence of bismuth in the tin-veins, of which we have already spoken, it is found in small quantities in the silver-veins in the andesites of Sierra de Guanajuato and Temascaltepec; in lead-silver veins in the Cretaceous limestones of Sierra del Carmen, Durango; in the Zapuri and Balleza mines, Chihuahua, and in the Doctor and Vizarron mines, Querétaro. Small bismuth-veins are known in the rhyolites of the Municipality of San Luis Potosí. It was in this Municipality that Prof. Cabrera first discovered the bismuth minerals.

Molybdenum.—Molybdenite is present in scales in the granulites near Temascaltepec, State of Mexico, and at some points in Oaxaca; in Cretaceous limestone at Zimapán, Hidalgo; Tetela del Oro, Puebla; the Canton of Mascota, Jalisco; and as an accessory mineral in the silver-mines of Nopal and Santa Inés, Guanajuato.

Antimony.—Stibnite and the oxides of antimony constitute the deposits, which are of two classes, according to the character of the enclosing rocks. The veins that are in the hornblende- and pyroxene-andesites have a course NE.–SW.; they

contain quartz and stibnite, with a small amount of galena and blende, very low in silver. The veins in the Cretaceous limestones and slates contain the oxides of antimony,—cervantite, stibiconite and valentinite,—which change to sulphides as depth is reached, and are very irregular. Antimony deposits occur in the Altar and Hermosillo districts, Sonora, and in the Sierras de Catorce and Charcas, San Luis Potosí. More commonly antimony accompanies galena, and in the upper part of the lead-veins it forms pockets and bunches of stibnite. As examples of antimony-veins in Cretaceous limestone we may mention those of Mazapil and Zimapán. Other antimony deposits are accompanied by mercury; these deposits, which are irregular and fill fractures and enlargements in Cretaceous limestones and slates, at Huitzuco, Guerrero, and Guadalcázar, San Luis Potosí, contain stibnite, livingstonite, kermesite and barcenite, with a small amount of cinnabar, in a matrix of gypsum, together with sulphur formed by the reduction of antimony sulphides and calcium sulphate.

Antimony is also present in the silver-veins of Molango, Hidalgo, and Zacualpan, State of Mexico; the stibnite accompanies argentiferous tetrahedrite in the veins which cut the metamorphic mica-schists; these veins seem to belong to the Tertiary age, but we have not sufficient data to confirm this opinion. At Rio Blanco, Querétaro, in the Cretaceous limestone, are deposits of stibnite, pyrite and cinnabar, with a matrix of gypsum. At Zacualpan the stibnite in some places accompanies argentiferous sulphides, forming pockets consisting exclusively of stibnite. In the Triunfo and San Antonio mines, Lower California, berthierite, jamesonite and a little stibnite always accompany the silver compounds, and in the oxidized zone antimony oxides and the antimonate of lead (bindheimite) occur. As depth is reached stibnite, jamesonite, berthierite, with galena, pyrite, zinc-blende and tetrahedrite, are found. This same association is also observed in some of the veins in Sonora which, like the Triunfo deposits, are in granulites and diorites.

Mercury.—Cinnabar is found at many places in the Republic, in veinlets and in the form of very irregular deposits. In the Cretaceous limestones poor deposits of cinnabar are found with a matrix of calcite and gypsum, accompanied by kermesite

and some stibnite; these deposits occur at Santa Rosa, Topoyapulco, district of Tenancingo, city of Ocuilán; also in Sierra de Encinillas, city of Santa Rosalia, Chihuahua, with oxides of iron; also in the mines of Targea and San Pedro de los Pozos, Guanajuato. At San Antonio de Bocas, Charcas, Guadalcázar, Partido de Venado, San Luis Potosí, and at Huitzuco, Guerrero, the cinnabar occurs with antimony. In the Cretaceous limestones of the city of Teloloapan, Guerrero, are veins of cinnabar, marcasite, kermesite and metacinnabarite with a calcite gangue.

Cinnabar occurs in hornblende-andesite in the Lorenzana vein of the San Sebastian mine, and in andesite in the vicinity of Chiquistlán, Jalisco; the deposit at Huajes del Partido de Juchipila carries quartz and cinnabar, forming veins in andesite. At Buenavista de Cuéllar, district of Alarcón, Guerrero, cinnabar is found impregnating pyroxene-andesite. Deposits of cinnabar are known in rhyolites at Pinos and Pedregoso, Zacatecas; San Juan de la Chica, Guanajuato; Arroyo del Lobo, Municipality of Encarnación de Diaz, Jalisco; Otinapa and Coneto, Durango, where it occurs in small veins accompanied by crystalline hematite; and at Zacualtipán, Durango.

Cinnabar is found in red conglomerates and volcanic gravels ranging in age from the Upper Miocene to the Pliocene. Such are those of Durango, Pedregal and Carro, San Luis Potosí; at San Cosme, Bañón, Tequezquite and some points near Pinos, Zacatecas; at Cerro del Pinolillo, Cerro del Gigante and the mines of Centeno, Guanajuato; and at Ajuchitlán and Tlachapa, Guerrero.

Mercury is also present in some silver-veins. In the Negrillas vein of the Pregones mine, lenses of almost pure cinnabar are encountered, together with galena, black blende, pyrites, chalcopyrite and argentite; in the Cinco Señores vein, Pozos, Guanajuato, cinnabar also occurs, in connection with pyrite and chalcopyrite,—the other minerals being similar to those of the Negrillas vein. In Tepic and Jalisco cinnabar occurs associated with tetrahedrite in some of the silver-veins.

Copper.—A large number of the copper-deposits of Mexico are to be considered as contact- or segregation-deposits, since they sometimes occur in a zone of decomposed eruptive rocks,

other times at the contact of eruptives and the Cretaceous limestones and shales. Very often the main ore-shoots occur directly in the limestone and the other part in the contact of the two formations. In Cretaceous limestone near the eruptive rocks—diorite, quartz-diorite and hornblende-andesite—there exist deposits probably formed by the circulation of hot waters that followed the intrusion of these rocks, which are intimately related to the contact-deposits that lie directly between the two formations. The frequency with which these contact copper-deposits are accompanied by iron-deposits in the contact zone, sometimes for a distance of ten meters or more from the contact, is also to be noted. The association of iron and copper is more intimate in some of the iron-deposits in which copper is a component, thus supporting the theory that the channels of water-circulation have divided and produced two classes of deposits which may reunite in depth. The gangue in these contact-veins is quartz; the ores are chalcocite, chalcopyrite and bornite. These are generally accompanied by grossularite, iron garnet, wollastonite, tremolite and vesuvianite, all of which are products of alteration, formed at the expense of the Cretaceous limestone through the agency of heated waters. As an example of these deposits may be mentioned the San José mine, Sierra de San Carlos, Tamaulipas, where the copper minerals, as well as magnetite and hematite, are present in the contact between quartz-diorite and Middle Cretaceous limestone. The deposits on the Cofradía property at San Juan de los Llanos, Puebla, and at Sierra del Carrizal, in Nuevo León, are identical with the above. The copper-veins of Tatatila and Zomelahuacan, Veracruz; Pánuco, Coahuila; Rio Florido, Chihuahua, and San José, Zimapán, Hidalgo, are also of the same type.

Copper in Eruptive Rocks.—Gold-bearing copper-veins occur in granulites (aplites) and Tertiary diorites in the Mina district, Guerrero, and at Cacoma and Ameca, Jalisco. They are composed of quartz with some zeolite at Cacoma. The oxidized zone is composed of gossan, copper carbonates, chrysocolla, native copper and gold; in the sulphide zone chalcocite, chalcopyrite and pyrite are found. In the mines of Cerro Blanco, Ajuchitlan, Guerrero, there are veins in granite, with a quartz gangue, and a NW.–SE. course; they contain, in the oxidized

zone, decomposed minerals (gossan), native gold, cerargyrite, copper carbonates and chrysocolla; as depth is reached, chalcocite, argentite and other silver sulphides occur. At Ojo Caliente, Zacatecas, the veins are in granulite, and have a WNW. course; part of them dip to the NE. and others to the SW. The minerals of these deposits are oxides and carbonates of copper and iron; as depth is reached sulphides of copper, iron and silver are met. At Inguarán, bornite, chalcopyrite and chalcocite are found in deposits in granite and quartz-mica-diorite. Oxides occur in the upper zone. Deposits in hornblende-andesite (?) or diorite (?) occur at Tepezalá, Aguascalientes, and Agostadero, near Villa García, Nuevo León, having a quartz matrix with bornite, chalcopyrite and garnet as a metamorphic mineral. In the oxide zone we find the carbonates and oxides of iron and copper and some chrysocolla. The deposits at the Palmarejo mines are in hornblende-andesite or trachy-andesite, have a NE.–SW. course, and contain quartz, tetrahedrite, chalcopyrite, pyrite, blende and silver sulphides.

In rhyolite, fissure-veins are known to occur in Chihuahua, and at Badiraguato, near Yedras; the deposits consist of carbonates and oxides of iron and copper in the upper part, and chalcocite and chalcopyrite below. At the Carmen mine, Durango, the copper-deposits are in the contact-zone of the rhyolite and Cretaceous limestones, and, according to report, pass into the rhyolite. They contain chalcocite and chalcopyrite with carbonates and some chrysocolla.

It is noteworthy that copper-deposits in Mexico occur in Tertiary acid rocks, such as granulites and rhyolites, contrary to the opinion of Fuchs, De Launay, Lapparent and others, who affirm that there exists an intimate dependence between copper-deposits and basic rocks in which, almost always, copper occurs in other countries. In Mexico it seems to be the neutral rocks which, either in themselves or at the contact with other rocks, carry the copper-deposits. The two cases we have cited of deposits in modern acid rocks are the only ones known up to the present time, aside from those that have been described in Japan. They are, therefore, of special scientific interest. Besides this exceptional association of copper with modern acid rocks, we have the occurrence of copper with

granulites and quartz-diorites, the former being acid, while the latter are considered neutral.

Native copper impregnates pyroxene-andesites (?) in the vicinity of Colucân, Puebla, forming deposits which appear to represent the inclusion-type of De Launay.

In the conglomerates and red sandstones of Upper Miocene to Pliocene age a number of copper-deposits are known, some belonging to the bedded-vein type, while others are reputed to be sedimentary deposits, but probably are bedded-veins. To the former type belong the deposits of Ajuchitlân, Guerrero, and some in Michoacân; to the latter those of Boleo, Lower California, and some similar deposits lately discovered in Michoacân. Gray copper is one of the argentiferous minerals almost always found in the veins of Lower California, Sonora, Sinaloa, Tepic, and some of the mines in Jalisco. Bornite occurs as the principal ore in the Guanaceví veins.

Lead.—The sulphide of zinc accompanies lead more generally than does antimony, and, like it, forms in streaks or bunches in the lead-deposits, so that in some parts the deposits will not pay to work for lead on account of the relative abundance of blende. No exclusive deposits of zinc are known, and many of the lead-deposits are in fact mixtures of lead and zinc. Lead and zinc are so constantly associated in the gold-bearing deposits and in the silver-veins, in which galena and blende accompany the silver sulphides in depth, that the presence of lead sulphide is a sure indication of zinc sulphide, and *vice versa.* The lead-deposits in the Cretaceous limestone and slates are generally related to eruptive rocks. The deposits in sedimentary rocks are more irregular and generally very poor in silver, while the deposits in the eruptive rocks are more regular and contain considerable amounts of silver.

Lead-Deposits in Sedimentary Rocks.—These are quite numerous, and often very irregular, being grottos or caverns in the sedimentary rocks filled with ore, which may perhaps be considered as substitution deposits; others occupy real fractures or veins in Cretaceous limestones and slates. At the Viejas and Villaldama mines, Nuevo León, irregular deposits fill cavities in the Middle Cretaceous limestones, the ore consisting of oxides, carbonates and sulphides of lead and oxide of iron, the galena being below. The Iguana mines, Nuevo León, are

bedded-veins of quartz carrying galena, pyrite and silver sulphides in limestone near diorite. The veins and irregular deposits at Santa Rosa de Múzquíz, Sierra Mojada and Mula, Coahuila, are of both classes, the veins having a course NW.–SE., with a dip to the SW. or NE. Among the irregular pocket-deposits may be mentioned Naica and Las Adargas, Chihuahua; Zimapán, Pechuga and Cardonal, and Lomo de Toro, Hidalgo; La Velardeña and Cuencamé, Mapimí, Durango; Cerralvo, Nuevo León; Caltepec and Santa Ana, Tehuacán, Puebla; Bramador, Jalisco; Sombrerete, Mazapil and Noria de Angeles, Zacatecas; and Huetamo, Michoacán.

The veins in the limestones and slates at Pregones mine have a course NW.–SE., dip to the NE., and are related to the Tertiary eruptive rocks, andesites and rhyolites. At the Noxtepec mines the veins have a course NW.–SE., and contain galena, blende, pyrite, argentite and pyrargyrite. In the San Carlos mine, Tamaulipas, the veins have a course NW.–SE., and are intimately associated with the eruptive rocks, diorites and basalts. At the Pihuamo mines the veins have a course N. 80° E. with a dip of 65° to the NW. The gangue is calcite, and the ore is silver-bearing galena and blende. These are contact veins between slates and limestones of the Lower Cretaceous above and granulites beneath.

Lead-Veins in Eruptive Rocks.—Veins occur in granite in the Desmoronado mine, and in hornblende-andesite at Cuale and Bramador, Jalisco, carrying galena in a quartz gangue. At Ojo Caliente, Zacatecas, the veins are in granulite; in these veins the relation between barite and the lead-bearing minerals is very curious, for in the veins where the lead enters in small proportions barite does not exist, or is only occasionally encountered, while in the veins rich in lead the barite is abundant and constant. At Etzatlán, Jalisco, there are lead-veins in Eocene diorites, the gangue being quartz and a small amount of calcite; the galena is disseminated as nodules resembling small pebbles.

Silver.—The silver-deposits proper are found in eruptive rocks. A very few are found in sedimentary rocks, and in these the silver is accidental and variable in quantity. Where silver-veins occur in sedimentary rocks, it is evident that they are related to and dependent upon andesitic Tertiary eruptive rocks.

Silver in Sedimentary Rocks.—The silver-veins of the mines San Javier, Los Bronces and La Barranca, Sonora, are in sandstones and slates, and contain chalcocite, tetrahedrite, pyrite, chalcopyrite, blende, a small amount of galena, and complex sulphides of silver in a gangue of quartz and calcite. The veins of the Urique mine, Chihuahua, are in Middle Cretaceous limestones and slates. They have a N.–S. strike and dip to the east. The vein-filling is quartz with calcite and gypsum, the mineralization of which is polybasite, pyrargyrite, argentite, pyrite, galena and blende. At Peñón Blanco, Zacatecas, the veins cut Cretaceous limestone, with quartz, calcite and barite as a gangue; they contain native gold and silver, carbonates of copper, and silver chloride in the zone of oxidation. In the sulphide zone the following minerals are found: argentite, stephanite, polybasite, stromeyerite, pyrargyrite, galena, pyrite, chalcopyrite and arsenopyrite.

In the mines of Pregones, Taxco and Noxtepec, Guerrero, the veins have a NW.–SE. course and they dip, some to the NE. and some to the SW. Various oxides are in the zone of oxidation; in the sulphide zone galena, pyrite, pyrargyrite and chalcopyrite occur. These veins are in Cretaceous limestone and are related to the eruptive rocks,—andesite and rhyolite.

The veins in the Sultepec mines are in the Lower Cretaceous shales (or slates) and have a course NW.–SE., with a dip to the NE. The gangue is quartz, with marcasite, pyrite, galena and chalcopyrite as the dominant minerals. These are accompanied by argentite, pyrargyrite, miargyrite and blende. Some of the veins in the oxidized zone contain pyrolusite and gypsum. In the mine of Fresnillo, Zacatecas, the veins are in Cretaceous limestone in which there are dikes and intercalations of a gray, spongy rhyolite. The veins cut diorites and, according to Arenas, spongy rhyolite (tufa) also.

Silver in Eruptive Rocks.—In the Cacachilas mines the veins are in granite or granulite, and consist of quartz with oxides of antimony and iron, chloride and bromide of silver, and carbonate of lead. Below these minerals, in the sulphide zone, may be found galena, tetrahedrite, sulphides of silver, berthierite, jamesonite, pyrite and blende. The same class of deposits is found in the diorites and granulites of San Antonio and El Triunfo, Lower California, and in various mines

of Sonora. In the Urique mines the veins are in Tertiary diorite, have a N.–S. course, and dip to the east; the gangue is quartz, and the ores are polybasite, miargyrite, pyrargyrite, pyrite and galena. In the oxidized zone, the oxides of iron and both the green and the blue carbonates of copper are found.

In the mines of Batopilas the veins are in diorite, generally with a N.–S. course; they contain an abundance of native silver, argentite, pyrargyrite, miargyrite, proustite, pyrite and galena. In all the veins here the matrix is quartz and calcite. At Desmoronado the veins are in granite. At Copalquín they are in quartz-diorite, and those of Matehuala occur in Tertiary porphyry, probably Eocene. Some of the veins of Guanajuato are in diorite. At San Andrés de la Sierra the deposits occur in a mica-quartz diorite with ophitic structure. The quartz gangue contains galena, blende, pyrite, pyrrhotite, arsenopyrite and complex sulphides of silver. These veins are considered by Tinoco as bedded-veins with a strike NW.–SE. and a dip to the NE. He classifies the country rock as hornblende-andesite. The veins of Ixtapan del Oro and some of those at Sombrerete are in granulite.

The majority of the silver-veins of Mexico are in hornblende- and pyroxene-andesite. As examples of fissure-veins in eruptive andesitic rocks, we may mention the following: In Zopilote, Tepic, the veins have a NW. course, and consist of quartz, blende and pyrite, sulphides of silver and small amounts of galena. At Topia the veins extend NE.–SW., and contain galena, blende, a very small amount of pyrite, argentite and pyrargyrite with a gangue of quartz and calcite. At the mines of Tecatitlán, Jalisco, the veins strike about N. 40° W., and dip 45° to the SW. The gangue is quartz with a little calcite, carrying sulphides and antimonides of silver, pyrite and chalcopyrite. At Chinipas, Chihuahua, the veins occur in diorite and hornblende-andesite. The strike is NE., or in some cases NW. The vein-filling is quartz with argentite and pyrite, oxides of iron and dendritic manganese. At Ajijic, Jalisco, the veins are in hornblende-andesite, with an E.–W. strike; there is an oxidized zone, and as depth is reached complex sulphides are encountered. At San Sebastián and Los Reyes, Jalisco, the veins have a quartz gangue with some calcite, complex sulphides and tellurides of silver and gold, a very little galena,

blende and pyrite. The veins of the Rosario mines and San Nicolás del Oro mine, Guerrero, are in hornblende-andesite; their course is NW., or in some cases NE., and they contain an oxidized zone. Below this is the sulphide zone, containing argentite, ruby-silver, pyrite and a small amount of chalcopyrite. The gangue is quartz carrying gold. Some of the veins of Sierra de Tapalpa, San José del Amparo and Rosario, etc., have a N.–S. course and dip W.; the gangue is quartz with some barite. In the oxidized zone they contain the carbonates of copper, and beneath this gray copper and stibnite occur. At Tlalchapa, Guerrero, the lodes have a NW.–SE. course, dipping to the NE. The vein-filling is quartz with argentite, pyrite and blende; occasionally the vein-quartz contains calcite, and, in addition to the minerals named above, galena and chalcopyrite. At the mines of Chacoaco, south of Fresnillo, the veins extend nearly north and south, and contain quartz with marcasite and pyrite. Some of the veins strike NE.–SW., and contain quartz, pyrite and sulphides of silver. The veins of Real del Espíritu Santo are found in augite-andesite.

In the pyroxene-andesites may be found the deposits of Pachuca, Real del Monte, El Chico, Tepenené, Capula, Santa Rosa, in Hidalgo; the mines of Santo Domingo, in Jalisco; and some of the mines of Noxtepec, Guerrero. Among the veins in andesite may be mentioned those of the following mines: San Pablo Analco, which in the oxidized zone somewhat resemble those of Pachuca; the California mines in which part of the veins strike NE. and dip SE., and others have their course towards the NW. and dip NE. The gangue is quartz, carrying galena, pyrite, chalcopyrite and tetrahedrite. In the San Rafael mine, Jalisco, the veins have a course N. 25° W. In the mines of Hostotipaquillo the veins contain calcite and quartz with some rhodochrosite, a small amount of pyrite and black blende, argentite, galena, chalcocite, and chalcopyrite. In the oxidized zone they contain native silver, carbonates of copper and a very small amount of copper oxide. It would be tiresome to enumerate all the silver-veins of Mexico which occur in andesites, but as has been said, the majority of the silver-veins of the country are in various species of this rock, which Humboldt designated as metalliferous porphyries.

Silver in Trachyte and Rhyolite.—The veins of the Bolaños

mines, according to Burkart, are in trachyte; but it is probably andesite covered by rhyolite. They have a N.–S. course, with deviations to the E., and a dip to the W. In the oxide zone may be found minium, litharge, cerussite and small amounts of copper carbonates. Below these there are tetrahedrite, ruby-silver, galena and pyrite in a gangue of fluor-spar and quartz. At the Cabrera mines, in Tepic, the veins are encased in a more or less silicified rhyolite. The Coronilla mines, Guerrero, are in rhyolite, and, according to Hoppenstedt, the veins have either an E.–W. or a N.–S. course. They have a quartz gangue, and contain argentite, ruby-silver and pyrite. Oxides occur only in the upper part.

Silver in Red Conglomerates of the Tertiary.—The veins of the Tepantitlán mines, Guerrero, occur in these rocks; they have a SE.–NW. course, and dip to the NE. or to the SW. The gangue is quartz, containing argentite, ruby-silver, black blende, arsenopyrite and a small amount of chalcopyrite. In the Tlatlaya group, according to Hoppenstedt, the ores form contact-deposits between andesites and Tertiary volcanic conglomerates. We may mention, furthermore, that the veins of Guanajuato cut the "bean-rock," as the miners denominate the "red conglomerate."

Of the mines of Huautla, Malacate, Temascaltepec, Zacualpan, Guanajuato, Catorce, Zacatecas and El Carmen, in Sonora, very satisfactory descriptions have been given by Fuchs and De Launay in their *Traité des Gîtes Minéraux et Métallifères.*

Gold.—Gold occurs in Mexico in exclusively auriferous, in auro-argentiferous and in cupro-argentiferous deposits. The first are in crystalline or metamorphic schists, pegmatites, granites, or diorites, and always in the proximity of recent eruptive rocks, such as andesites and rhyolites. The second are in trachytes and hornblende-andesites, which are closely related to the more recent rhyolites and basalts. And, finally, nearly all of the cupro-argentiferous ore-deposits are in the contact between the Cretaceous sedimentary rocks and the granites, diorites and Tertiary hornblende-andesites.

Gold in Granite.—The mines of Santa Clara, Real del Castillo, El Alamo, Camalmahí and San Borja, Lower California, are in granite. In the Santa Clara mine the veins have a course from N. 20° W. to N. 70° W., with a dip to the SW.,

or, in some cases, vertical; they contain quartz and auriferous pyrite; the gossan carries some manganese oxide and native gold. The veins of Calamahí have a course N. 35° W., and contain quartz, auriferous pyrite and some sulphides of copper. The zone of oxidation carries oxides and free gold. Judging from the amount of silver that accompanies the auriferous pyrite in the veins of the San Borja mines, they will probably change to silver-veins as depth is reached.

Gold in Pegmatite.—The numerous veins of Sierra Pinta del Bajío in the Altar district, Sonora, are in pegmatite which cuts crystalline schists. These veins appear to be related to the micaceous trachytes that skirt this mountain range. The veins carry quartz, pyrite, chalcopyrite, a very small amount of galena and blende, and contain free gold along the crests. The veins suddenly pinch out along both the course and dip, and present a well characterized lenticular formation resembling a string of beads.

Gold in Granulite and Diorite.—The veins of the Tajitos, Rastrita and San Antonio mines, Sonora, contain quartz with free gold in the upper part. As depth is reached, pyrite, galena and blende are found. In some veins the last two are relatively abundant. Chalcopyrite and chalcocite occur in abundance in other veins. The veins of the Alameda mine, Opodepe, Sonora, are in granulite and strike NE.–SW., with a dip to the SE. They contain native gold and silver, horn-silver and sulphides of silver. As depth is reached, the veins are more auro-argentiferous. They are in part covered by rhyolites. The veins of Barranca del Oro in Tepic and Parnaso, Pijintos and Cerro de San Antonio near Ameca, Jalisco, are in granulites, which are cut by dikes of diorite and hornblende-andesite. The Barranca lodes have an east and west course, and contain quartz, pyrite and a little galena. The veins of Parnaso, Pijintos and Cerro de Antonio contain quartz, auriferous pyrite and sulphides of copper.

The mines of Peras and Santa Catarina Tlaxila, Oaxaca, and the Republic mine, Jalisco, are in diorites. The veins of the first are narrow, and contain quartz with auriferous marcasite, antimonial galena, and a small amount of blende and chalcopyrite.

The veins of Puerto del Oro, Guerrero, are known to be in

crystalline schists, and contain quartz, with pyrite, chalcopyrite, galena and blende. Those in the Realito mines, Sinaloa, contain quartz and auriferous pyrite. In the San Cristóbal mine, between the districts of Tavares and Bravo, Guerrero, the veins have a NW.–SE. course; dip to the SW.; are in crystalline schists, but pass into andesites, and have a quartz gangue carrying argentite, pyrite, chalcopyrite and a small amount of galena, thus forming a transition from gold-bearing to silver-gold-bearing veins. In the Los Ocotes mine, District of Sultepec, State of Mexico, the veins in phyllite are intimately connected with pyroxene-andesite. Their course is NW.–SE., with a dip to the SW. They contain quartz, a small amount of pyrite, argentite, arsenopyrite, and are rich in native arsenic.

The Cretaceous limestones of Campo Morado, Guerrero, show Eocene granulitic dikes, with veins of contraction and cooling, carrying quartz and auriferous pyrite.

Gold-Silver Deposits.—In Andesites.—At the Taviches mines, Oaxaca, gold-silver deposits occur in hornblendic andesite. The veins have a N. 50° W. course; dip to the SW.; and have a gangue of quartz and calcite, accompanied by some fluorite, gypsum and rhodochrosite. In the oxide zone, chloride and bromide of silver, free gold and native silver, are found. Pyrargyrite, miargyrite, proustite, polybasite, argentite, stibnite, pyrite, galena, chalcopyrite and a very small quantity of blende, are found in the sulphide zone.

In the Ixtlán mines, Tepic, the lodes have a course N. 50° W. and contain quartz, pyrargyrite, polybasite and a small amount of argentite. Native silver occurs in the oxide zone. At Cerro Colorado, Chihuahua, the veins form a network in altered hornblendic andesite. The gangue is calcite and quartz carrying free gold, pyrite, and chalcopyrite rich in silver. At San Josê de Gracia, N.–S. veins in hornblende-andesite carry auriferous pyrite, galena, blende, and silver sulphides in a quartz gangue.

In Hornblende-Trachyte.—The vein at Mezquital del Oro has a NE.–SW. course and dips to the NW. It contains quartz, iron oxides and free gold in the upper part, and as depth is reached the quartz contains chalcopyrite, pyrite and sulphides of silver. This vein is very close to the rhyolites which cover the trachyte.

In Tlalpujahua gold-silver veins occur in Jurassic and Cretaceous slates, related to Pliocene rhyolites which extend over the slates. Their course is N. 25° W. and they dip to the NE. In the oxide zone there is free gold and native silver. The gangue is quartz which carries argentite, pyrite, pyrargyrite and polybasite, with a small amount of stibnite in some of the veins. At Mineral del Oro the poorer veins are in the slates of the Jurassic and the better ones in the Cretaceous, and are related to the andesite flows which cover the sedimentary formation. These veins contain quartz with auriferous pyrite and carry free gold in the upper part.

Gold-Copper Deposits.—Contact-deposits between diorites and Cretaceous limestone are found at Zomelahuacán, Tatatila, Veracruz, which are connected with pyroxene- and hornblende-andesite; at the mines of San José, Tamaulipas, which are related to the basalt that covers and intersects the diorites; at the Encarnación mines, Hidalgo, which are associated with eruptive andesite; and at the Pánuco mines, Coahuila, deposits which are closely related to the eruptive hornblende-andesite.

Historical Sketch of Mining Legislation in Mexico.

BY EDUARDO MARTÍNEZ BACA, MEXICO CITY, MEXICO.

(Mexican Meeting, October, 1901.)

INTRODUCTION.*

ALTHOUGH Mexico has always been justly considered by the whole world essentially a mining country, this reputation is due principally to the richness of the deposits which have been worked. In reality, the majority of the States have been little

* SECRETARY'S NOTE.—This paper was prepared by the distinguished author at the request of the Department *de Fomento.* The greater part of the Introduction, omitted in this translation, consists of general statements concerning the importance of the mining industry throughout the world, and especially in the Republic of Mexico, not only as a direct producer of wealth, but also as a support to other industries and a factor in the development of commerce, the increase of population and the progress of civilization.

explored, and some, such as Guerrero and Chiapas, are almost entirely unknown. Innumerable denouncements for the exploitation of mineral-deposits have been recorded since the colonial epoch, and innumerable mines have been (for reasons that it is unnecessary to enumerate in a work of this character) completely abandoned; but enough has been done to demonstrate the considerable number and extent of mineral deposits in Mexico.

On account of the new character given to mining-properties by the law of 4th June, 1892 (now in force), and in compliance with the dispositions of Article 2 of the law of 6th June of the same year, miners had to present the titles to their properties for registry.

The area of mining-properties thus registered since the law of 1892 went into effect has been approximately 5400 *hectaras*. The number of titles issued by the *Secretaría de Fomento*, in accordance with this law, from the beginning of 1893 to December, 1900, was 12,871, with an area of 130,078 *hectaras*.

To this number should be added, approximately, 48,692 *hectaras* which are exempt from taxation, because they are special concessions granted by the *Secretaría de Fomento* under the law of 6th June, 1887, and which were exempted by Article 4 of the law of 6th June, 1892. Thus there were, up to 31st December, 1900, titles covering 184,170 *hectaras*. This number does not include the great zones, the exploration and exploitation of whose mineral resources was conceded by Congress to the Companies "El Boleo" and "El Progreso," in Lower California; "Malatos," in Sonora; "Patopelas" and "Pinos Altos," in Chihuahua.

It should be noted that ownership in many of the registered mines has been lost by failure to pay the annual tax, and also that not all of them are now worked; for under the law of 4th June, 1892, already mentioned, it is necessary only to pay the stipulated tax in order to retain the ownership, and, within the concessions mentioned above, work in all the mines is not obligatory.

According to data published by the Statistical Bureau of the *Secretaría de Fomento* for the year 1900, the number of laborers employed in the mines and reduction-works was as follows:

	Men.	Women.	Children.	Total.
Mines, ...	99,396	1,288	5,852	106,536
Reduction-Works, .	27,777	76	1,339	29,192
Total, ...	127,173	1,364	7,191	135,728

In this number the other employês of the companies and the other laborers, who, directly or indirectly, make their living from the mines, are not included.

In 1900, the exportation of metallic and non-metallic mineral productions was $79,000,000, or 59 per cent. of the total exports ($134,000,000) in that year.

These data place beyond doubt the importance in Mexico of the mining industry.

The Geological Institute of Mexico, established by decree of 1888, the present director of which is the accomplished and learned engineer, D. José G. Aguilera, has made important studies of the geology of the country, which have not only made known many of the mineral deposits hidden in its soil, but have also furnished useful information to those engaged in their development.

By a natural process of evolution, mining legislation in Mexico has necessarily followed the industry to which it relates; but the transformation that has taken place in this legislation has certainly been more radical than that of the industry governed by it. From one extreme it has gone to the other. The former strict limitation of the *pertenencias* which could be conceded, the obligation to employ a given number of workmen, the imminent danger of losing the property, either by failure to work, want of drainage, of ventilation, etc., have given place to entire freedom in the number of *pertenencias* which may be conceded to one person, and complete liberty of action to work or not to work the holdings, the owner being obliged only to respect the rights of his neighbor and to subject himself in the workings to the Regulations governing the police and security of mines. The property thus acquired is now irrevocable and perpetual, and is not to be lost except in the case of failure to pay the tax established upon the unit of surface-measurement.

The purpose of this paper is to give an historical summary of mining legislation in Mexico. The endeavor will be made to give an idea as complete as possible of the regular and methodical advance which it has followed in its different transfor-

mations, without going minutely into details, for a complete history of our legislation would fill volumes. Mention will be made, therefore, of the fundamental constituents of each of the different laws issued, except those which have a purely fiscal character, since they can be better reviewed elsewhere. Finally, these notices will be preceded by a few words on Mining in Mexico before the Conquest.

The points, therefore, which will be briefly touched upon in this very imperfect paper will be:

I. Brief Notes on Mining in Mexico before the Conquest.

II. Mining Legislation during the Spanish Domination. The Mining Ordinances of 1783.

III. Mining Legislation of Mexico, before the Constitution of 1857, and the Legislation of the States, while they enacted Mining Laws.

IV. The Mining Code of 1884 and the Law of 1887.

V. The Law of 4th June, 1892, now in force, and Circulars relative thereto.

VI. Conclusion.

I.

Brief Notes on Mining in Mexico before the Conquest.

History has shown us that the working of deep mines was unknown to the Aztecs, and that if they did undertake some works on veins these were of very little depth. The reason is clear. Since they were ignorant of the manner of separating the useful and valuable part of the ore from the useless, it was utterly futile for them to extract the ore from the veins. They limited themselves, therefore, to exploiting gold and silver which they found in the native state, whether from the placers in the beds of rivers or from the outcropping of veins. It seems, also, that the working of these deposits did not constitute a true industry, and for this reason there were no laws governing it. Tributes payable to the kings must be in gold or silver, and, therefore, the tribute-payers were obliged to obtain these metals whence they could. Such a form of tribute-paying shows that the Aztecs understood very well the true value and significance of these metals.

By this means the kings or rulers were enabled to accumulate great treasures, and history gives us an account of the

immense riches of the Emperor Moctezuma. Hernán Cortés, in a letter to the King of Spain, dated 30th October, 1520, in which he gives an account of the progress of the war of conquest he had undertaken, says that in Tlaxcala* he found "jewels of gold and silver and stones and other jewels of feathers, as well made as could be found in any of the markets of the world."† He further says, in the same letter, that all the commissions sent by Moctezuma to dissuade him from going to Mexico made him rich presents of gold, and that when he reached the presence of Moctezuma, this monarch presented him with two collars, "and from each collar hung eight Camarones of gold of great perfection, nearly a span long."

"Respecting the service of Moctezuma [continues the Conquistador] and the wonderful things of his greatness and state, there is so much to write that I declare to your Majesty that I do not know where to begin in order to tell you a part of them only; because, as I have said already, what more magnificent greatness could there be than that a barbarous lord like this should have counterfeits in gold and silver and stones and feathers, of everything under heaven found in his dominions, and, withal, so natural, and the objects of gold and silver so made that there is not a gold- or silver-smith in the world who could make them better. And as for the objects of stone, it is impossible for the judgment to understand with what instruments they were made so perfect, and those of feathers could not be made so marvelously of wax nor in any embroidery."‡

The treasures accumulated by Hernán Cortés were great also, and, in order not to tire my readers with quotations, I shall merely call to mind the difficulties he experienced in his vain endeavors to save them in the memorable "noche triste."

It appears, also, that another of the reasons why the ancient inhabitants of this continent did not undertake the exploitation of the subsoil was the richness of the superficial deposits and the facility with which gold and silver could be extracted from them. Then, again, to a certain point, the application of these metals was limited to the payment of tribute and the fabrication of certain ornaments, principally for the use of the nobles. Therefore, the exploitation of these deposits not being on a large scale, and being free, there was no need of legislation to govern it. It is true that the Indians did possess and work mines, but this was after they had seen the Spaniards working

* Tlaxcala means the "country of bread," on account of the abundance of wheat and maize produced there.

† *Letters of D. Fernando Cortês*, p. 78.

‡ *Letters of D. Fernando Cortês*, p. 158.

them and had learned the method of treatment employed to extract the useful material.*

Taxco (Guerrero), Pachuca (Hidalgo), Sultepec (Mexico), Tlalpujahua (Michoacán), Guanajuato and Zacatecas were the districts in which the Spaniards first began mining. When once mining had been introduced into the country, it became necessary to regulate it; and then came the first laws dictated by the Spanish government.

II.

Mining Legislation During the Spanish Dominion: The Mining Ordinances of 1787.

The laws promulgated by the King of Spain, and observed all over his vast conquests, were naturally similar to those governing the same subjects in Spain.

Certain laws were issued even before the termination of the conquest, and scarcely had it been accomplished when many others followed.†

In the Code of the Indies (*Recopilación de Indias*), ordered published by Charles II., are to be found various laws and dispositions relating to mining. I shall cite the principal ones promulgated for the kingdoms of the Indies:

1519. Law 1st, Title xxii., Book iv., orders that the gold of ransom received (*rescate*) from the Indians in manufactured pieces, be assayed, certified, marked and charged with one-fifth to the crown.

1525. On the 24th November, in Toledo, the emperor Charles ordered in Law 2d, Title xix., Book iv., that the miner and all

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* It is calculated that 80 per cent. of the silver produced in Mexico, at least till fifteen years ago, was obtained by the system called the "patio" process, invented by D. Bartolomé de Medina in 1557, in the reduction-works called "Purísima Chica," in Pachuca.

† All historians consider the 13th August, 1521, as the end of the Conquest of Mexico. On that date the troops of Hernán Cortés occupied the "Gran Tenoxtitlán" after a fiercely-contested battle, in which, it is said, a greater number of Indians were slain than of Jews in the destruction of Jerusalem by Vespasian. The letter of Hernán Cortés, giving an account of this victory, was received in Spain on the 1st March, 1522, and was printed in Sevilla the 8th November of the same year by Jacob Cromberger Alemán, as the first fruits of the art of printing in Sevilla and, perhaps, in all Spain, after the Complutensian Bible, published at the expense of the Grand Cardinal D. F. Francisco Ximénez de Cisneros and celebrated as the first work printed in that country.

others who should gather gold should appear before the Governor and royal officials and, under oath, should show it and declare it in person at the proper office.

By Law 3d, Title xxii., Book iv., the quality of gold in plates and ingots was to be determined by assay, but if in manufactured jewelry the "points" should suffice.

1526. By Law 1st, Title v., Book viii., the discovery and working of mines was permitted upon notice to the Governor and royal officers.

1530. Law 3d, Title xix., Book iv., orders that when any premium shall be promised to those who discover mines, only two-thirds of the premium shall be paid from the royal treasury, and the other one-third by the persons extracting the metal.

1535. Law 4th, Title xxii., Book iv., orders that gold shall be melted without admixture of other metals and shall pass current for its value.

1551. The foregoing disposition was confirmed and added to by Law 2d, Title xxii., Book iv., wherein it is ordered that gold and silver shall be assayed and melted and shall pass current for their value and fineness. Law 14, Title ix., Book iv., was of the greatest importance and significance. It declared that the Indians might hold and work mines of gold, silver and other metals; and that no Spaniard or cacique should have a part in the mines discovered, held, or worked, by Indians.

1557. Law 7th, Title xxii., Book iv. No one shall melt down gold or silver taken for ransom, nor shall metal taken from the mines have other sign than the mark of the mine.

1559. By Law 3d, Title xx., Book iv., the alcaldes, judges, and notaries of mines are prohibited from forming partnerships with the owners of mines or with their discoverers. By Law 16, Title xix., Book iv., the same rights are conceded to the Indians upon measuring their mines as to the Spaniards.

1568. Law 1st, Title xix., Book iv., amplifies the foregoing prohibition. It permits all Spaniards and Indians who are vassals of the king to discover and work mines, except magistrates, governors, city officers, mayors and their lieutenants, alcaldes and notaries of mines, and that all who were especially prohibited and excluded from indicating, taking and staking out mines should keep the laws and ordinances of this province, this being confirmed by the king.

1572. It is ordered in Law 1st, Title xx., Book iv., that favor be shown to miners and quicksilverers, and especially that no levy for debt (except debt tó the Crown) shall be made on the slaves, tools and other articles necessary for the development, working and possession of their mines and for the persons working in them, and the levy is limited to the gold and silver extracted and obtained from the mines.

From 1575 to 1596 there were several laws of but little importance.

1601. By Law 13th, Title xix., Book iv., lazy Spaniards, half-breeds, free negroes and mulattos were obliged to hire themselves to work in the mines.

In 1602, Laws 1st, 2d, 4th and 5th, Title xix., Book iv., were promulgated. These ordain that the governors (*alcaldes mayores*) of mines must have ability and experience in the working of mines; that imprisonment for debt of miners must be in the place and district in which the mine where they worked was situated, and that they may not be removed therefrom; that the authorities shall take care that all materials received for the supply of the mines and reduction-works be sold at just prices, and that legal proceedings, in which miners are involved, shall receive the utmost despatch.

In the years 1603, 1609, 1610 and 1617, by Laws 7th, 4th, 10th, 9th and 12th of the Title and Book just cited, it is ordered that the scoria, silt and washings shall not be thrown away in the mines; that the viceroys and governors shall encourage the discovery and working of quicksilver-mines, making such concessions as they shall deem just to the discoverers and miners; that they shall decide in council whether it be better or not to tax the mills for grinding ore; that they shall especially encourage the discovery, improvement, and working of mines; and the sale of ores to those not owners of mines is prohibited under severe penalties. The same prohibition was extended to the alcaldes by Law 2d, Title xx., Book iv., in 1618.

1629. Law 6th, Title xix., Book iv., orders the observance of the ordinances, adding that he who does not work his mine for four months shall lose it, and that it may then be denounced by anyone as abandoned. It is also forbidden to grant favors or extensions of the established period.

1630. Law 5th of the same Title and Book commanded that the ordinances of mines and particular laws should be kept and observed. Among the latter is especially mentioned that which orders that a person working for another may not denounce a mine for himself, but only for his employer.

1633. In order that they should disclose their knowledge, premiums and exemptions were awarded by Law 15th to the Indians, who should make known mines the existence of which they had hitherto kept secret.

The "Ordinances of Mines," to which Laws 5th and 6th, Title xix., Book iv., of the years 1629 and 1630, just mentioned, refer, were promulgated in Madrid 18th March, 1563, by King Philip II. They contain seventy-eight ordinances and constitute Law 5th of the same Title and Book. The 22d of August, 1584, Philip II. had issued new ordinances in San Lorenzo, revoking only those parts of former ordinances which were inconsistent with them. These ordinances of 22d August, 1584, contain eighty-four chapters, and figure in an especial manner in Law 9th, Title xiii., Book vi., of the Code of Castile.

These laws are commented upon by the notable jurist and commentator, D. Francisco Xavier de Gamboa, in his celebrated work, *Commentaries on Mining Law.* He gives them the name of *Ordenanzas del Nuevo Cuaderno* (Ordinances of the New Pamphlet), to distinguish them from the former, which he calls *Ordenanzas del Antiguo Cuaderno* (of the Old Pamphlet). Under the Ordinances of the New Pamphlet, the radical possession of mines of gold, silver and other metals rested in the Sovereign, who exercised over them the unquestionable right of sovereignty (*regalía*), under a system called "freedom of the mines."

In addition to these laws, King Charles made a decree (*cédula*) which was published in Granada on August 22, 1527, ordering that, in the mines of New Spain, whoever wished might take out gold, silver and other metals without let or hindrance. In Madrid, the 19th July, 1540, he issued another decree, ordaining that no execution against a mine should be issued against the tools used in working it, but only against the gold- and silver-products.

Still another decree, issued in Madrid 7th January, 1549, prohibited, under heavy penalty, those to whom Indians had been assigned from constraining them to work in the mines.

The Law of 28th February, 1550, given in Valladolid by the Queen Regent, renewed to the Viceroy, D. Luis de Velasco, the instructions to visit the mines either in person or by deputy, in order to make sure that no violence was done the Indians working in them.

And the Law of 31st July, 1554, given from the same place, forbade lawyers to intervene in the business of mines.*

December 24, 1771. The Viceroy of New Spain made a report to King Charles III. setting forth: that in order to improve the decadent state of mining, to radically and effectively (*cómodamente*) correct the obnoxious abuses introduced between the miners and operatives, and, in consequence, to avoid the reciprocal complaints which resulted, he considered the formation of new general ordinances most opportune and urgent, and, at the same time, he proposed the means which he judged most conducive to serve as a sure guide to the successful execution of such an important work.

After consultation with the Supreme Council of the Indies, and in accordance with its recommendation presented 12th June, 1773, the King of Spain, by decree dated 20th July of the same year, authorized the formation of these ordinances. At the same time, he named a Board (*Junta*) composed of four ministers satisfactory to him; and, in compliance with their opinion, he gave orders to the Viceroy that, in the formation of the new ordinances, he should procure the formation, arrangement and establishment of a formal and united mining corporation in imitation of the Consulates of Commerce.

On their part, the miners of New Spain presented a petition to the Viceroy, asking:

> "Not only to form themselves into a corporation like the Consulates, as had been commanded, but also to establish a bank *de avios*, to give impulse to the mines, to create a college of metallurgy, and that a new code of the Ordinances of Mines shall be drawn up."

This manifesto having been approved by the King of Spain, the miners appointed their representative deputies, who, having met, proceeded to organize the miners into a corporation, to the designation of its offices, and the nomination of the in-

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* For more details, consult D. Santiágo Ramírez, *Riqueza Minera de Mexico*, 1884, from which these notes have been taken.

dividuals for officers, all of which was approved by the Viceroy by decree of 21st July, 1777, and communicated to the King; and, by royal order of 27th December of the same year and of 20th January, 1778, it was commanded that if the newly-established corporation had not yet formed its ordinances, it should hasten that work;

"Which, entrusted to Sres. D. Joaquin de Velázquez Cárdenas de Leon and D. Lucas de Lassaga, was concluded on 21st May of the same year, and remitted to Spain 26th August, 1779, accompanied by the fiscal opinion (*parecer*) of the Real Audiencia and the judgment of the Assessor-General of the Vice-Regency."*

These documents were examined by ministers of renowned probity, who presented their judgment, and, after careful consideration, the Ordinances of Mining were issued in Aranjuez on 22d May, 1783, and were published and solemnly proclaimed in Mexico, 15th January, 1784, by the Viceroy, D. Matías de Gálvez.

Believing this document worthy of being known, I copy it here:

"D. Matías de Gálvez, Lieutenant-General of the Royal Armies of H. M., Viceroy, Governor and Captain-General of the Kingdom of New Spain, President of the Real Audiencia, General Superintendent of the Royal Treasury and Department of Tobacco, etc.

"With the most important object, meditated upon many years before being arranged, of encouraging and giving due heed to the interest and improvement of the exceedingly rich and innumerable mines of New Spain, the indefatigable care and solicitude of the King, our Lord (whom may God guard), has been pleased to send me by this last post the new and appropriate Royal Ordinances for the rule and government of the important Corporation of Mining of these Kingdoms, and his Royal Tribunal-General, comprised in the Royal decree dated from Aranjuez 22d May, 1783, in which His Majesty, stating first the proceeding which preceded the considerations of this most weighty matter and everything else which occurred during them, includes all the ordinances in 19 Titles, and concludes as follows:

"Lastly, I order and command the Governor and all those of my Supreme Council and Chamber of Indies, Royal Audiencias and Tribunals of New Spain, its Viceroy, Captains or Commandants-General, Governors, Intendants, Ministers, Judges, and other persons who may or could be affected, in all or in part, by the dispositions and proscriptions of said ordinances, that they govern themselves strictly by them, making effectual and observing with the greatest exactness that which corresponds to each one, holding everything contained in them as a perpetual and firm Law and Statute, keeping them and causing them to be observed inviolable, notwithstanding whatever other Laws, Ordinances, Establishments, customs or practices there might be to the contrary, for, in so far as there should be

* *Op. cit.*, p. 733.

any such, I hereby expressly revoke them and desire that they be of no effect; forbidding, as I do, that they shall be interpreted or varied in any manner, because it is my will that they be precisely according to the letter and express meaning. And, so also, I command most strictly all Tribunals, Magistrates and Courts, included in this and the foregoing article, that they contribute to and assist efficaciously the punctual obedience to every disposition and command in these, My Royal Ordinances, avoiding, by every means possible, all competitions and embarrassments which will incur my Royal displeasure as prejudicial to the Administration of Justice and to the good government, quiet, and happiness of the important Corporation of Mining of these, My Dominions. To which end I have ordered the despatch of the present decree, signed by my Royal hand, sealed with my secret seal, and countersigned by my undersigned Secretary of State and of the Universal Office (*Despacho*) of the Indies. Of this, their Comptroller-General's office will take note, as also the Corresponding Offices of New Spain.

"Given in Aranjuez on the 22d of May, 1783.

"I, THE KING.—*Josef de Gálvez.*—It is a copy of the original. *Josef de Gálvez*—marked with a flourish.

"And having remitted the printed copies which came to the said Royal Tribunal-General with the official note of 19th December of the past year, 1783, it begged that I should please order the due obedience and compliance with the said Royal Decree and Ordinances in accordance with their contents. So I immediately decreed in conformity with the previously solicited opinion and petition of the Fiscal, who, among other things, says, as follows:

"Lastly, it is proper that you should make a Proclamation that should be addressed, without delay, to all the Governors, Magistrates, Mayors and other Justices of these Kingdoms, in which shall be made known to all the inhabitants the context of the Royal Decree of 22d May of this year, and that Your Excellency should command them most strictly that they contribute to and aid efficaciously the compliance with its dispositions and commands, and with all and every one of the Ordinances in their 19 Titles; it being well understood that, although, at present, no copies are sent, because there are not enough at hand, this is no reason why they should be unmindful of their dispositions, which will be communicated opportunely, and, in the meantime, will be made known in special cases by the respective territorial Deputations.

"Mexico, 23d December, 1783.—*Posada.*

"And, in consequence, that it may reach the notice of all, I order that it be promulgated and published by Proclamation (*Bando*) in this Capital and in all the other cities, towns and villages of these dominions, and in all the mining districts, in order that the said Royal Ordinances may be observed, kept and complied with due punctuality as fixed Laws and Statutes belonging and peculiar to mining, printed copies of which have been distributed to the Tribunals and Ministers of this City and sent out to the principal mining places, and as soon as a sufficient number are received copies will be sent to all the others.

"And that the Royal Tribunal-General of this important body be held and considered by all the others with the respect conducive and proper to the ultimate ends with which the Sovereign dignity has endowed it; and, moreover, that it enjoy and use all the jurisdiction, rights and powers that have been conceded to it in said Royal ordinances, and that it be respected and obeyed by all whom, in any manner whatsoever, it may or can effect, under the grave penalties incurred by those disobedient to their Judges and transgressors of the laws and sovereign orders of the King.

"And, to this effect, copies of this proclamation are sent, as there have been of

ordinances, to the Presidency and Regency of the Royal Audiencia of Guadalajara and to the Commanding-General of the interior provinces for their instruction and government, while giving the necessary orders for their publication.

"Given in Mexico, 15th January, 1784. *Matías de Gálvez.*

"By order of his Excellency."

These ordinances won the admiration and the enthusiastic eulogies of entire generations. As the renowned advocate, D. Ignacio L. Vallarta, says, they were ahead of their times. It can be said that they were in force for more than a century, since, in reality, the principles established in those ordinances —particularly those relating to the acquisition and conservation (retention) of mining property—continued in existence till 1892. Neither in the codes of Durango and Hidalgo, the only States which issued special legislation on mining during the period in which the States possessed this power, nor in the Mining Code of 1884, promulgated to unify the legislation on mining in the whole Republic, were their authors free from the inspiration of the principles established by the Ordinances of 1783.

According to them, the Paramount Dominion of the mines resided in the Royal Crown which, without separating them from its Royal Patrimony, conceded them in property and possession, on the condition that the miner should contribute to the Royal Treasury a stipulated portion of the metals, and that he should not suspend work in the mines for more than a stipulated time, under pain of losing the property if he failed to comply with any of these requisites, in which case the mine could be adjudged to any other person.

There were various considerations which governed the granting of mining claims, and which had to be taken into account when the denouncement was presented: whether it was presented by an individual only or by a company; whether or not by the discoverer, and in case that he was the discoverer, whether the discovery referred to a new mining district or to a new vein in a district already known.

In the first case, three continuous or interrupted (alternate) *pertenencias* on the vein that he should designate, and one more on each of the other veins discovered, were conceded to the discoverer if he should designate all these within the term of ten days; in the second case only two *pertenencias* were con-

ceded to the discoverer, and if the denouncement was made on a vein and in a district already known, the denouncer was not considered a discoverer and was conceded only one *pertenencia.*

If the denouncement was made by a company, it could cover four continuous *pertenencias* without preventing the attainment also, in case of discovery, of the same rights as were accorded by this title.

The dimensions of the *pertenencias* were, treating of veins, 200 varas (167.60 m.) on the strike of the vein, measuring horizontally, and at right angles the width varied according to the inclination or dip of the vein from 112½ varas (94.28 m.) to 200 varas. In placers, pockets (*rebosaderos*) or other irregular deposits of gold and silver, the territorial Deputations of mining regulated the dimensions of the *pertenencias*, taking into account the extension and richness of the deposits and the number of denouncers, being required to report to the Royal Tribunal-General of Mexico, which should take final action.

The miner could work not only within the limits of his own *pertenencia*, but also could enter those adjacent "with vein in hand," dividing with them the ores that he should take out.

Unnaturalized foreigners were prohibited from acquiring and working mines. Members of religious bodies of both sexes were also prohibited from denouncing or acquiring, in any manner, either for themselves or for their convents or communities, any mine; and those of which they should be possessed were required to be sold within the term of six months. Neither could mines be acquired by the governors, intendants, magistrates, alcaldes, mayors, or by other justices of mining places and "camps," nor yet by the notaries in them; but they could hold mines in territory separate from that of their jurisdiction. The employés of mining enterprises could not denounce, nor in any manner acquire, mines within a zone of 1000 varas on all sides of the company's property, unless it were for the company or for the owner of the mine where they were employed.

Mining property was lost by failing to work the mine four continuous months with four operatives, or eight months interruptedly in a year, counted from the day of obtaining possession. If the pillars, stulls or safety-piers were removed

from the mines or weakened, the operative who did this was punished with ten years of prison; the same punishment was inflicted upon a mine-guard who permitted it; and the owner of the mine lost the property, together with one-half his goods, and was, moreover, excluded forever from following the business of mining.

The Tribunal, called "The Royal Tribunal-General of the Important Corporation of Mining of New Spain," was established by the dispositions of this same ordinance. It was composed of a president, a director-general and three deputies-general. These duties must invariably fall upon practical, intelligent and expert miners, who had had more than ten years' experience in the mines.

The President and Director-General were for life. The deputies were chosen at an election held every three years in the City of Mexico by representatives of all the "*Reales de Minas*," provided with adequate authority by all the miners. By *Real de Minas* was understood those places in which there existed a town already established with church, vicar or curate, Royal Judge (Judge of Mines) and Deputies of Mining, six mines in operation and four reduction-works. These were also Deputations of Mining in the Mining Districts, which were called Territorial Deputations. They were composed of two Proprietary Deputies and four alternates, and were renewed by halves every two years. The Deputies of Mining were named from among the inscribed (registered) miners. These were only those who had worked on their own account one or more mines for more than one year. Those who gave funds to work mines (*Aviadores*), ore-buyers (*Maguileros*) and owners of Reduction-Works also took part in the elections, but each two were allowed only one vote, and they could not be Deputies unless they were also miners. The Royal Tribunal-General of Mining had cognizance of all Gubernatorial, Directive and Economic questions concerning mines. It could also take cognizance of cases in which were involved questions relating to discoveries, denouncements and measurements of *pertenencias*, to drainage, desertions and depillaration of mines, to the furnishing of money to work mines (*Avio*) or purchase ores of silver, gold, lead, copper, to smelting charges, etc., but it could only exercise this jurisdiction of contested cases within a radius of twenty-five leagues from the City of Mexico.

The Royal Tribunal could have an attorney in the city and at the Court of Madrid, who should represent it in all matters relating to mines of which it had cognizance and which should come before that court.

The Territorial Deputations were subject to the Royal Tribunal. They were charged with taking cognizance of and giving legal course to denouncements of mines, and with vigilance for exact compliance with the ordinances in working them; they could also take cognizance in contested matters, of the same cases as those assigned to the Royal Tribunal and entirely independent of it, outside its territory, as above designated.

The sentences in mining questions were summary; no delays or writs were admitted. In every dispute the parties were summoned to appear personally in order to end the difference, and, if this were not accomplished, their written petitions were admitted, if they were not disposed, ordered or signed by lawyers.

The parties could appeal from the sentence pronounced, if the amount in dispute exceeded $400; if less, no appeal was admitted, but the sentence pronounced by the Royal Tribunal or by the Territorial Deputations was executed.

The appeals had to be presented within three days of notification of the rendition of judgment.

Appeals from the Royal Tribunal were presented before the Court of Appeals (*Alzadas*) established in Mexico, and composed of a judge appointed by the Viceroy, the Director-General of Mining and another miner; those from the Territorial Deputations before the Court of Appeals ordered to be established in Guadalajara, whenever such Deputation was within a zone of twenty leagues from Guadalajara, which was assigned as the Jurisdiction of this Court.

In each province there was also a Court of Alzadas to hear the appeals from the other Deputations. They were composed of the judge of highest authority in the province, appointed by the King and two miners.

Even by an inattentive reading of the Ordinances of 1783, their dominant idea is understood. It was to encourage and stimulate the exploitation of mines by all possible and adequate means. Work was obligatory. Trials and judgments were

brief. Imprisonment for debt was in the mines themselves, so that the debtor could work in them. All who dedicated themselves to the working of mines were conceded the same rights and privileges as the miners of Castile and Peru. The privilege of nobility was conceded to the engineers of mines, so that they should be looked upon and attended to with every distinction. A special fund was formed for the creation and maintenance of a college of mining, dedicated exclusively to the education of engineers of mines.*

Finally, they go so far as to order the Judges and Deputies of the mining towns and precincts to counsel, and, if necessary, admonish (*amonestar*), the miners, and especially those whose mines were *en bonanza*, to the end that they should not squander their riches and spend them foolishly, lest their mines fall into the hands of those who were not miners.

Before bringing to a close this part of my already tedious paper, I cannot refrain from giving extracts from two Articles, one of which refers to the education and teaching of the youths (young men) destined for the mines, and the other which recommends vigilance to the miners lest they squander their funds.

The first says:

"Considering that industry makes the ordinary (*medianas*) and even the commonest productions of nature useful for human life, while, on the contrary, without it, even the advantages and benefits which ought to be expected from the most subordinate natural riches generally become useless and disappear, I wish, and order, that the industry applicable to mining, and which is worthy of such a place therein, be excited, encouraged and fostered, especial care and attention being given to observe the use and effect of the machines, operations and methods that are at present employed in it, so that all which shall be found truly useful and perfect of their kind may be preserved in all their integrity; that they may not insensibly lose and diminish their worth, as has happened and happens; and that those things which, compared with the best and surest rules, are found to be worth mending and reforming, may be brought to really greater perfection and more effective practice, without hampering the progress of the industry by ancient prejudices cramped in caprice and ignorance, nor yet having its just preservation endangered by poorly-founded novelties."

The second says:

"Being so notorious and pernicious, the immoderate freedom with which the miners are accustomed to spend their funds, consuming them with the greatest

* The College of Mining was inaugurated January, 1792, with an endowment of $250,000.

imprudence and disorder until they and their families are soon left in misery and their means in the hands of others who do not invest them in mine-working, it is my sovereign will, and I order the Judges and Deputies of mining towns and camps to counsel, and, when necessary, to admonish the miners, especially those whose mines are *en Bonanza*, not to consume their wealth in extravagant and vicious expenditures, nor in vain liberality; and when this is not sufficient for the correction of these abuses, that they report them to the Royal Tribunal-General of Mining, in order that, having carefully judged the reproachable conduct of the miner under consideration, it may appoint a trustee for him or in some other manner provide for the preservation of his goods as for a veritable spendthrift (*verdadero pródigo*)."

Various isolated laws were given after the Ordinances of Mining were issued.

Manufactured articles of silver were subjected to the *quinto* (fifth); the provision of salt in mining camps was ordered; the operatives in the mines were exempted from military service; the utensils, provisions (*abastos*), dry goods and articles which were introduced into and consumed in the mining camps were freed from the duties of *alcabala* (*octroi*), as were also the other articles necessary for the work of the miners, which were called "the eleven free species (*especies*)."

Premiums were established for the inventors of metallurgical processes for ores; the price at which powder was to be sold to the miners was fixed, and the penalty of confiscation was imposed upon all metals which were found without the Treasury-mark of their origin.

Of all the later dispositions, those which had the most intimate relation with the ordinances were the Law of 18th July, 1789, repealing Art. 18, Title i., of the Ordinances; that of 31st May, 1790, which declared that, in default of the five proprietary members of which the Tribunal should be composed, when the General Junta was holding meetings, the precise number of four votes—of the Director, of two Deputies and of the Consultor—should concur in them, that of 12th February, 1797, in which Art. 2 of Title iii., of the Ordinances was repealed, and Art. 4 of the same Title amplified, and that of 10th June, of the same year, restricting to the Tribunal the power of discharging certain employés.

The 26th of January and 2d of February, 1811, the General Cortes and the Supreme Council of the Regency conceded the acquisition and full dominion of quicksilver-mines, free commerce in their products and exemption from all kinds of duties,

offering premiums to explorers and to inventors or perfectors of metallurgical processes.

The last Royal order issued by the Colonial Government was that of 19th December, 1818, in which the King declared that quicksilver intended for the reduction of ores ought not to pay eventual duties of *alcabala* (*octroi*), or any other tax.

Such, in rough outline, is the history of mining legislation in Mexico during the Spanish domination.

III.

Mining Legislation of Mexico before the Constitution, of 1857, and the Legislation of the Several States while They Enacted Mining Laws.

The Independence of Mexico having been consummated 27th September, 1821, the expulsion, in 1827, of the Spaniards, in whose hands were nearly all the principal mining enterprises, the truly difficult conditions in which the country found itself in consequence of the sanguinary and prolonged war of Independence, and the imperative need of the newly-established government to fix its attention preferably on other matters, were powerful reasons why mining in Mexico should have been plunged into a state of almost complete paralysis.

The Ordinances of Mining continued in force throughout the country, as there had been no order suppressing them; and as the newly-established Government could not ignore such an important industry, as soon as more pressing demands for attention permitted, it turned to the matter and endeavored to remedy the bad conditions in which it was found, effecting the dispositions that appeared most conducive to that end.

The 20th February, 1822, the Junta Provisional issued a decree which abolished the duties on bullion of silver and gold, and established as the sole tax the 3 per cent. of the value of these metals. The costs of coinage and parting were established; the *feble* (legal variation in weight) of the coins was fixed; the expert requirements necessary for the technical employés of the mints and parting-offices were determined; quicksilver (liquid), no matter what its origin, was exempted from duties; and powder was ordered to be sold to the miners at cost.

In 1823 rules were made for the collection of the duties on gold and silver; the conditions required to enable a foreigner to acquire property in mines were set forth; and moneys remitted to mining towns were excused from the duty of 2 per cent.

By the decree of 20th May, 1826, the Tribunal-General of Mining was suppressed, although it was, provisionally, formed into a board called the "Provisional Junta of Mining," while the "Establecimiento of Mining," ordered by the same decree, was being constituted. By the decree of 15th September, 1829, the employés of the Establecimiento of Mining were substituted for the Commissaries-General in the collection of the duties for the endowment fund of this establishment. In 1842 various decrees and circulars were issued considering the natives (Indians) and foreigners as discoverers of mines if they could prove that they had restored abandoned mining-camps. It was provided, also, that these foreign partners of discovery or restorative companies should retain their property, even though they should absent themselves from the territory of the Republic for any cause and during any time, provided that the companies in which they were partners should continue in existence. The *Junta de Fomento y Administrativa* ("Board of Encouragement and Administration of Mining,") to take the place of the "Establecimiento of Mining," was formed and its rules made. To this Junta was conceded the privilege that the mines which the Establecimiento of Tasco had inaugurated could not be denounced during two years.

Many decrees and dispositions were issued in 1843. The old Deputations of Mines were continued in the exercise of their functions while the Courts of Mining were being established. The Courts of First Instance were authorized, after hearing the miners of the district (*comprensión*), to form the schedule of the fees that the Territorial Deputies and their secretaries should charge. The *Junta de Fomento y Administrativa* of Mining was authorized to contract a loan up to $2,000,000, either within or outside of the Republic, with the object of procuring the contract for the quicksilver of the mines of Almadén. The collection of the duties imposed on cloths and fabrics of cotton, established by the law for the encouraging of mining, was arranged. The observance was ordered of all the dispo-

sitions given by the Ordinances of Mining of 1783, to favor the exploitation of mines of quicksilver, freeing them from all impost, and conceding a premium of $25,000 to each of the first four exploiters who should, in one year, take out 2000 quintals of quicksilver (liquid), conferring upon them, moreover, other franchises. The *Junta de Fomento* was authorized to work, provide with funds, and protect the mines of quicksilver, and to order deposits of this metal to be examined and surveyed. It was ordered that, in the Department of Jalisco, a special fund should be formed for the exploitation of mines of quicksilver, for which purpose the Departmental Junta of that State was authorized to place a loan, and, if unable to negotiate it, an impost on such trades as should be considered most appropriate in order to raise the sum of $100,000, which should be used exclusively to encourage mines of quicksilver in that department.

The appointment was ordered, of at least one commission in each department to scientifically examine and work the deposits of cinnabar. Finally, the manner of renewing the President and colleagues of the Courts of Mining of First Instance was made known.

The Decree of 30th April, 1844, was occupied with the establishment and arrangement of the powder factories so as to reduce the price to miners.

That of 28th June, 1852, arranged the mining fund.

In 1853, the following Decrees were issued:

That treating of miners and their creditors, that permitting miners to manufacture powder, and that establishing the Practical School of Mines and Metallurgy in Fresnillo, Zacatecas.

The Law of 31st May, 1854, regulated the judicial, governmental and administrative relations of mining. The circular of 7th November of the same year ordered that the Deputations of Mining should be continued without any change, and the Decree of 23d December set forth the salary that the members of the Tribunal of Mining were to receive.

The Decree of 12th March, 1855, annulled Article 34 of the law relative to contests in the Deputations of Mining, Title 4th of the Ordinances of Mining remaining in force with respect to this. The Decree of 28th April permitted the exportation of ores from Lower California for three years. This

permission was extended for five years more by the Decree of 3d February, 1857. The Decree of 25th June, 1855, declared that the placers of Arizona belonged to the nation, and the law of 23d November authorized the Judges of Common Rights (*Fuero Común*) to have cognizance of mining matters. The Decree of 3d January, 1856, re-established the Deputations of Mining, reducing their functions to the economico-governative; Art. 3 of this Decree declaring that in the States in which there were no Deputations of Mining the economico-governative powers should reside in the Governors, who exercised them according to the terms fixed by the Ordinance and through the interior political authorities, to whom were presented the registers and denouncements to be forwarded to the Governors.

The Decree of 1st February declared that foreigners resident in the Republic could possess mining properties.

The Decree of 10th September, 1857, reformed Articles 2, 4, 5 and 7 of the Ordinances of Mining, this reform being that the measurements of the *pertenencias* should be in metres and not in *varas* as they had required.

In January, 1861, a circular was issued ordering that the collection of fees destined for the support of the College of Mining should be expedited, and by the Decree of the 26th of the same month the Fund of Mining was extinguished, entering into the Public Credit, the government charging itself with the support of the College.

The Law of 29th May of this year provided for the appointment of commissions to reform the Ordinances of Mining.

In 1865, it was ordered that every miner should have a representative in the place in which his mine was situated; the legal formalities under which were made denouncements for abandonment of bad workings of mines were set forth, and the dimensions of the *pertenencias* of non-metallic substances were fixed.

The Circulars of 17th December, 1867, and 9th May, 1868, refer to the formation of mining statistics.

An order of the Treasury Department, dated 16th May, 1868, established a Junta of Mining to propose opportune fiscal modifications.

The Decrees of 9th, 10th and 24th December, 1871, 26th January and 2d March, 1872, refer to the exportation of gold and silver coin and bullion.

The Decree of 8th May, 1873, authorizes certain mining companies of Zacatecas to export, free of duties, the sum of $250,000 for the purchase of quicksilver.*

All the laws, decrees and circulars just mentioned were issued by the General Government; and since upon the promulgation of the General Constitution of the Republic, 5th February, 1857, among the powers of the Congress of the Union, detailed in Article 72, that of Legislation on Mining was not included, but, on the contrary, it was provided in Article 117 that the powers not expressly conceded to the Federal functionaries should be understood to be reserved to the States, to them was reserved, in consequence, the power of legislation on mining.

All of them preserved the Ordinances of Mining of 1783, which remained in force for many years; for, although the States of Durango and Hidalgo did issue special mining codes, it was many years later. In all the States, the Deputations of Mining were suppressed; and in some, special regulations were made, which I proceed to review.

In the Territory of Lower California, the Department of Mining was subordinate to the Political Governor of the Territory, who resided in La Paz, and to him were remitted, by the Sub-Prefects of the districts, the denouncements and other matters relating to this department.

Under date of 27th June, 1874, the Political Governor of the Territory issued a regulation to formalize the proceedings in this department. This was in force till the Mining Code of 1884 was issued, and, judging from the information it has been possible to obtain, mining in that Territory has been in great decadence since. From April, 1866, to January, 1885, 152 denouncements were presented in the Territory, and of these in only ten was possession given.

The government of the State of Sonora, in exercise of the powers which pertained to it as a Territorial Deputation, in conformity with the law of 3d January, 1856, issued a circular, under date of 12th October, 1863, providing, among other things, that no Judicial or Administrative authority should demand fees from miners under any pretext, and that miners should not pay for giving course to their writs or for the protection of their mines other fees than those set forth in the Ordenanzas.

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* Olmedo y Lama, *Appendix to the Ordinances of Mining*, and Ramirez's *Riqueza Minera de Mexico*.

The same government, by Decree No. 9, dated 24th October, 1879, established a tax of $20 for each title of mines that it should issue, and by circulars of 4th December, 1876, 5th April and 26th November, 1880, 8th January, 28th July, 6th August, 12th September and 26th November, 1881, provided that the Prefects should see that the provisions of Articles 2, 3 and 4 of Title xiv. of the Mining Ordinances, in respect to the purchasers of ores, were maintained in all their vigor and force in the State, and determined what stamps should be placed on titles of mines, what conditions shall be satisfied by denouncements in order to be registered, and the length of time, after taking possession, within which miners were required to provide themselves with a title. They also provided that coal-deposits could be denounced in the same way and under the same prescriptions as those of other (*sic*) metals; that, in the same communication, petitions for the extensions of time on different (*varias*) mines should not be permitted; that, in the denouncements of mines by foreigners, the Prefects, in addition to the reports required to be given by experts, should report also whether the said foreigners resided in the State, in what part of it and during what time, and that whenever the Prefects should receive a denouncement, a petition for extension of time or other official communication in relation to mining, they should immediately remit a simple copy of it to the government.

Decree No. 16, of 3d December, 1881, issued by the above-mentioned government, established a tax of $8 for the registry or denouncement of mines; of $5 for each month of prorogation (extension of time) or protection (*amparo*) solicited, and of $32 for each title issued, rules being given in the same decree for the manner of paying this tax.

By circulars of 30th November and 2d and 14th December, 1881, it was made known that whoever presented proof of having first paid the corresponding fees would be considered the first denouncer; that the time of the prorogation conceded to a mine having elapsed, it could not be considered as protected, in any manner, by Articles 13 and 14 of Title ix. of the Ordinances of Mining; and that course should not be given to any petition for prorogation that was not accompanied by the report of a mining expert and of the Prefect of the corresponding district.

Decree No. 24, of 24th December of the same year, 1881, declared to be denounceable mines of coal, bitumen, sulphur, asphaltum, petroleum, salt, saltpetre, alum, kaolin and precious stones. It designated the dimensions of each of these *pertenencias* and established the legal formalities to which the denouncements must be subject.

The Executive of the State was given authority to make contracts for the exploitation of these substances.

In the State of Sonora, according to what it is possible to gather from official notices, from 1870 to 1884, possession was given to 817 mines.

In the State of Coahuila, under date of 22d June, 1827, Decree No. 40 was issued to provide for the establishment of a Deputation of Mining in the mining district of Valle de Santa Rosa. This Deputation should be composed of the Alcalde, or whoever acted in his stead, and two residents, to be elected by an absolute majority of the vote of the town council of the Valle. This Deputation could appoint commissioners with cognizance of matters relating to mining in the new mining-camps outside of its immediate limits.

Under date of 29th February, 1868, the same State issued Decree No. 31, which I believe worthy of particular consideration, because it gives an idea of the condition of mining in that State during the time referred to.

The preambles which served as the foundation of this decree terminated as follows:

> "And adding to this that in Coahuila the industry of mining presents a perspective of decadence and abandonment which already touches its complete ruin if the Legislative Power does not extend to it a protecting hand that will give it animation, lift it from the low condition in which it is, at the same time awakening in the inhabitants of the State the mining spirit which has disappeared almost entirely, the conclusion has been reached, in view of these considerations, to decree, etc."

In virtue of this decree no fees were collected in the State from those interested in mining enterprises for the presentation, judicial decree and other legal actions necessary in denouncements, including the advertisements required to be made in public places; the denouncements of mines could be either verbal or in writing. If a person working a mine, even though he had not received possession of it, could prove to the Gov-

ernment, either verbally or in writing, that he was in want of funds to continue the work, the Government aided him by giving him gratis the blasting-powder he needed for daily consumption. The judge who gave possession of a mine should demand no pay whatever, and if the one thus favored wished voluntarily to make a present to him or to a member of his court, they could accept it if it did not consist of any share or right in the mine, and if it should not be construed to be a practice and custom in cases of its kind. The experts should charge only $10 for the examination of a mine and the other operations that were necessary for them to perform, and if the miner had no funds to meet this expense, the Government aided him with half the amount as a loan, to be paid back. Reduction-works and the capital invested in them were exempted for five years from the payment of municipal and State taxes. Finally the decree ends as follows:

"Art. 19. To favor the mining spirit in the State in a positive manner, and, at the same time, to avoid the injuries and even destruction caused by the ignorance, want of proper knowledge, and precipitation of those who venture upon ruinous enterprises without having sure and certain data regarding the richness of an ore, the Government is authorized to establish, in this capital, a Reduction-works for the assay of ores by fusion, for which only the actual cost shall be charged, and a monthly bulletin of the results given by the ores assayed shall be published.

"Art. 20. The Government shall establish an assay office successively in the capital of each of the districts of the State."

Coahuila was the State that protected mining the most, but, unfortunately, its endeavors were without avail, for, according to official State reports, no possession of mines was given during the time in which it had the power of legislating on mining. Now, as is well known, it is one of the greatest mining States.

In the State of Nuevo León only the Ordinances of 1783 were in force, since the Government did not dispose otherwise; but it will be sufficient to form an idea of the condition of mining in that State, during the epoch under consideration, to say that from 1853 to 1883, thirty years, possession was given to seventy mines.

The State of Jalisco, by Decree No. 451, dated 13th October, 1873, suppressed, in all the State, the territorial Deputations of Mining which had been re-established by the general de-

cree of 3d January, 1856, the Judges of First Instance exercising the economic-gubernatorial functions with which the deputations had been charged.

By the Decree No. 54 of 19th October, 1883, that of 25th April, 1829, was repealed, leaving in full force Article 22, Title vi., of the Ordinances of Mining; and coal-fields were expressly covered by it.

The Decree of 27th September, 1887, provided that metallurgical establishments should pay a single tax of 6 per thousand instead of the 12 per thousand they had been paying, and that the products of the mines should pay 1 per cent. on the value of ores extracted, without deductions of costs.

There is no information in regard to the number of denouncements and possessions conceded during the epoch under consideration. It is only known that from 1883 to 1884 judicial protection was granted for suspension of work for from two to three years in a considerable number of mines, without loss of property in them.

The State of Durango issued an especial Mining Code, in which it was declared that mines belonged to the State; the origin of property in mines was denouncement and adjudication; mines were lost by failure to work; the legal formalities to be followed in denouncements and other proceedings relative to mining were established; and the Ordinances of 1783, as well as the other laws and dispositions made anterior to this code, were repealed.

The State of Guanajuato issued the law of 5th May, 1867, which treated of mining in an especial manner. It determined the manner of procedure in the different cases that could happen in the application of the law; it organized the Deputations of Mining; designated what were to be the dimensions of *pertenencias;* the legal formalities to be followed in denouncements, etc. It also exempted every one employed in the work of the mines from military duty and from municipal commissions.

The State of Puebla issued a law 23d June, 1880, exempting coal-mines from all tax, and offering premiums to the exploiters of this combustible mineral. The law of 3d October, 1881, declared denounceable certain substances comprised in Article 22 of Title vi. of the Ordinances of Mining, regulated

the denouncements, fixed the dimensions of the *pertenencias*, and authorized certain protections. The law of 9th August, 1882, and its subordinate regulations, dated 26th of the same month, offered a premium to the exploiters of coal-mines who complied with certain requisites.

In the other States the principal dispositions related essentially to taxes, and in the majority of them mining was heavily charged.

The State of Guerrero, by its law of 23d April, 1875, suppressed the Deputations of Mining, their functions being exercised by the Governor of the State through the interior political authorities. The legal formalities to be followed in denouncements, and the cases of opposition presented were established. The works of possession were dispensed with when treating of irregular deposits. Under date of 29th of the same month and year, the regulations under the foregoing law and the tariff for the fees of the experts were issued.

In the State of Hidalgo, even when a special mining code had been issued, the Ordinances of 1783 were in force for some time—also several decrees were issued before the promulgation of this code. They were the following: Decree No. 29, dated 30th September, 1871, by which mines were considered to be divided into twenty-five *barras* (shares); of these, one non-assessable belonged to the Government, which had the same rights, powers and obligations as the other non-assessable shareholders. Afterwards, it was published, by decree No. 410, Fraction iii., Article 1, that mines acquired before the foregoing decree, and in which the Government had owned no non-assessable share, should pay to the State 4 per cent. on their earnings.

Decree No. 156, of 30th September, 1872, established a tax of 8 per M. on reduction-works, and 2 per cent. on the value of the silver extracted. By No. 213, of 13th October, 1874, the mines or deposits of iron-ore in the State were exempted from the tax on mines, as also from the duties granted to the State by Decree 129. By Decree No. 181, dated 26th September, 1877, all mines in which the government held a non-assessable share were exempted from the payment of the tax of 4 per cent. levied on paying mines.

The State of Hidalgo issued its Mining Code the 10th October, 1884. By it, mines of metalliferous substances and com-

bustible minerals were declared to pertain to the radical dominion of the State, which could grant them in property and possession to the private persons, whether citizens or foreigners, who solicited them, according to the rules and under the conditions fixed by the same code.

The Executive of the State was encharged with economic and governative functions in the department of mining. The *Jefes Politicos* (Prefects) were his intermediaries in this business. Denouncements could be made of new metalliferous deposits, abandoned mines, mines in ruins, sites and water for reduction-works, and of abandoned reduction-works. In recognition of the radical dominion of the State over all metalliferous properties within its territory, there was assigned to it one "preferred" non-assessable *barra* of the twenty-five into which the mines were divided.

A preferred non-assessable *barra* was understood to be one which conferred upon the Government the right to receive profits (earnings) as soon as the operating expenses were paid, even though the other non-assessable shares received nothing yet. The legal formalties, to which denouncements and other proceedings relative to mines must conform, were established, and the Ordinances of Mining of 22d May, 1783, were repealed, as also all the former laws and dispositions that had been issued concerning mining.

Later than the foregoing Code, by Decree No. 417, of 3d May, 1882, the payment of the 4 per cent. on mines in earning, referred to in Decree No. 410, was regulated, and the tax collectors were authorized to arrange commutations (*iguala*) for this tax.

Decree No. 423, of 10th October, 1882, fixed the fees that should be paid the Prefects for mining proceedings that came before them, and also the fees of experts for work done by them. Decree No. 467, of 11th May, 1885, established a tax of 2 per cent. on the production of mines without deduction of expenses; as provided by the Mining Code of 1884, it returned to the dominion and profit of the owners of the mines the "preferred" non-assessable *barras* belonging to the State in various mines; and the 4 per cent. to be paid by mines earning profits was annulled.

There were others issued, but they reglamented the payment of the established taxes.

The last one issued was No. 487, dated 27th March, 1886, which ordered that the gold and silver extracted from the mines should pay $1\frac{4}{10}$ per cent. on their value, and that gold- and silver-ores should pay 2 per cent. on their assay-fineness.

The same decree prescribed the manner of payment of this tax. Many other decrees were issued, but they related to legal protection (*amparos*) granted to mines.

Oaxaca was one of the States most prominent for the interest shown in mining from an early date, the encouragement and development of which it stimulated by appropriate dispositions.

The law of 10th September, 1857, abolished legal fees; of 8th December of the same year designated 1,000,000 square meters for the *pertenencias* of coal-mines; of 10th December, 1858, fixed the salary and obligations of the Secretary of Mining; of 15th May, 1876, disposed of the internal arrangements of the Territorial Deputation; of 17th December, 1883, declared free from every kind of tax the capitals employed exclusively in mining; the mines and reduction-works; ores in any form extracted from the mines of the State, as well in their interior circulation as in their exportation; machinery, quicksilver, iron, powder, dynamite, and fuse intended for use in the mines.

My friend, the distinguished engineer, D. Gilberto Crespo y Martínez, in a notable speech pronounced in the Chamber of Deputies during the session of 30th November, 1886, in the discussion which was the cause of the law of 6th June, 1887, spoke at length on these taxes, which he qualified as absurd.

The diversity of the laws governing mining during this epoch, the distinct and often opposing opinions concerning this industry held in many of the federal entities, the heavy taxes upon the industry, were all more than sufficient causes for the slow, torpid development of mining. These obstacles were made more patent when in the case of a mineral-deposit, which extended from one State into the adjacent one; for then the mining-properties established on this deposit were subject to two different legislations, and these properties, which by law and by their nature were indivisible, presented the anomalous case where part of them incurred the penalty of abandonment, according to the State in which it belonged, and the other part did not incur a like penalty, also in conformity with the legislation of its State.

The necessary consequences of this condition of affairs was to damage seriously the development of mining.

Notable writers and persons well informed in the subject, by means of reasonable and well-founded articles published principally in *El Explorador Minero* and *El Minero Mexicano*, called the attention of the Supreme Government to the necessity of introducing fundamental reforms in the mining legislation.

The Secretary of Justice appointed a Commission composed of two mining engineers and two lawyers. One of the engineers resigned from the Commission. The other members, on the 8th May, 1874, presented a draft of a mining law for the Federal District and the Territory of Lower California. This project did not become a law, and, as it naturally did not remedy the evil existing in the whole Republic, it was necessary to seek some other means.

IV.

The Mining Code of 1884 *and the Law of 6th June*, 1887.

The late General Carlos Pacheco, to whose energy, talent and activity the country owes so much while Minister of *Fomento*, and his honest, faithful, laborious and accomplished sub-Secretary, Engineer D. Manual Fernández Leal, were both constantly animated by the best intentions, and always disposed to do all in their power within the sphere of their functions, to encourage and develop all the branches of industry at that time dependent on their Ministry. Great benefits to the country were the results of their noble conduct.

They soon perceived, as it was natural that persons of such aptitudes and honorable purposes should, the imperative necessity of remedying in a radical manner the difficult and almost disastrous conditions in which mining, our principal industry, was found.

Very soon the Department of *Fomento* initiated the formation of a society, called the "Mexican Society of Mining." The Secretary of *Fomento*, as representing the First Magistrate of the Nation, presided at its inaugural meeting, held 5th February, 1883. Before this, the members of the Board of Direction had been appointed, and also the Committees on Encouragement (*Fomento*), Statistics, Sciences, Legislation, Publication and Means (*Arbitriós*). The Society, having been inaugu-

rated, proceeded to organize the personnel of its membership, electing honorary and active members and *juntas* of correspondents. A Special Committee was also appointed, composed of learned and practical men of known honorable antecedents, to propose what franchises should be granted to capitals invested in mining.

This committee, the members of which were General P. Diaz, Jesús Fuentes y Mũniz, Benito Gómez Farías, immediately complied with its charge, presenting an interesting report well founded and reasoned. In it the authors give proof not only of having studied the question to the bottom, but also of great zeal and efficacy in the discharge of their commission.

They conclude, proposing:

1. The endeavor, by all direct and indirect means that the General Government may consider expedient, to arrive at a uniform mining legislation, inspired by the letter and spirit of the old Ordinances of Mining.

2. Suppression of the General Imposts which weigh exclusively on mining and, if possible, uniform legislation throughout the Republic; establishment of a single general impost on mining products in such manner that it does not touch the capital, but only the income or profits,—part of this impost to be handed to the respective States.

3. Recommendation to the States by the General Government to free from *alcabala* (*octroi*) all articles destined for consumption by exploiting and beneficiating miners, charging local imposts exclusively upon the income and profit, but never upon the capital invested in mining.

4. Reduction of the fees for coinage and parting in all the mints, when they should come under the direct administration of the General Government, upon the termination of the leases.

5. The urgent necessity of publishing a collection of mining-maps of the principal mining-districts of the Republic, with text, giving information on all points concerning the exploitation of mines and the beneficiating of ores or minerals; and, also, notes on the principal and mother-veins, deposits of coal, lignite, petroleum, cinnabar, etc.; and on woods, water, and topographic and climatic conditions.

6. Exemption, for periods of one to three years, from Federal tax on foreign or Mexican capital destined exclusively to

mining enterprises, so that, during the time of trials and unproductive preparatory work, capital intended for such a beneficial industry should not be heavily charged.

7. Concentration in the Mexican Society of Mining of all the data, notices, statements, plans and reports, which could serve, by opportune publication, to encourage foreigners and Mexicans to decide to invest capital in mining.

The first Committee on Legislation, of the two appointed by the Mexican Society of Mining, formed by the lawyers, Messrs. Pedro Escudero and Pedro Bejarano, and the engineer, Santiago Ramírez, after holding various meetings, also presented a report to the Board of Direction proposing that, with due attention to the legal requisites, the General Constitution be amended with the intention of giving the power of legislation on mining to the Congress of the Union.

This report was approved by the Board of Direction and sent to the Secretary of *Fomento;* and the President of the Republic, on 16th May, 1883, recommended its passage to the House of Deputies.

It was passed by a large majority of both Houses.

With some amplifications and modifications, it was approved by nineteen and rejected by only two of the State Legislatures.

In virtue of this reform it, therefore, became a power of the Congress of the Union, "To issue Codes of Mining and Commerce, banking operations being included in the latter, which shall be obligatory in the whole Republic." December 14th, 1883, this amendment was promulgated, and on the 15th of the same month the Executive was authorized to issue the Mining Code which should have force in the whole Republic.

The Minister of *Fomento* immediately proceeded to appoint a commission which, taking into account the laws existing in all the States and in other countries, should draft a Mining Code.

This Commission was formed of Lawyer Pedro Bejarano, Engineers Manuel M. Contreras and Santiago Ramírez, with Francisco Bulnes, Secretary; but Sr. Ramírez, not being in accord with the Commission on certain points, withdrew from it and was charged by the Secretary of *Fomento* to present his draft of a Mining Code also.

Sr. Ramírez, as well as the rest of the Commission, presented projects, and the Secretary of *Fomento*, wishing to pro

ceed in such a delicate business with all caution, invited the States to appoint representatives to revise these projects and make such observations as they should think pertinent. Twenty-two States responded to this invitation and appointed representatives. Some of the criticisms of the representatives were published, the most interesting being that of Lawyer Ignacio L. Vallarta, who represented Sinaloa. He compares the two projects with each other and with the Ordinances of Mining. The project of the commission was approved, with some modifications, and published under date of 22d November, 1884, to go into effect 1st January, 1885. As stated by the commission in the preamble, for the most part it followed as a foundation the principles established by the Ordinances of Mining, believing that it would be improper and dangerous to alter them.

Having given, now, an idea of the provisions of the old ordinances, I shall proceed to merely note the more unusual differences.

By the Code of 1884 greater extent was given to the *pertenencias;* denouncements could be made, not only for abandonment, but also for improper working, want of drainage and want of ventilation; the period of abandonment, according to the old Ordinances, was four months, the Code of 1884 extended it to six. Moreover, it authorized the Deputations to grant protection for six months, and the Minister of *Fomento* could grant other protection in special cases for one year.

The taxes were reduced to 2 per cent. on the value of the metal without deduction of costs. This tax was for the State in which the mine was situated, or for the Federation, if in the Federal District or the Territory of Lower California; also the duties of coinage and exportation were to be paid. Reduction-works paid the same tax as other industrial establishments.

The Government received 25 per cent. of the foregoing taxes.

Deposits of coal and its varieties, as also deposits of iron and tin, belonged to the owner of the ground, along with the rocks and other matters of the soil.

For the period of fifty years mines of all varieties of coal, of iron and of quicksilver, with their products, were exempted from all direct taxes.

Within the Republic gold and silver, either in bullion or

coin, were allowed circulation free from any tax, as was also the case with the other metals and with all the products of the mines. Quicksilver continued exempt from importation duties and all direct taxation.

By Article 218, the Ordinances of Mining of 22d May, 1783, were repealed, as were also the other laws, decrees and dispositions relating to mining of the Colonial period, of the Federation or of the States, even in the part not opposed to the new code.

Mining legislation in the whole Republic thus unified, without doubt a great step in advance was taken, and the industry was placed in relatively favorable conditions for a rapid development; but, either because the law, through want of comprehension, was not properly interpreted, or because some of its provisions were abused, the result, in my opinion, did not correspond in an entirely satisfactory manner to the noble aims of its authors.

The present writer, who, without being worthy of it, has been for several years at the head of the Bureau of Mines established under the Department of *Fomento* by the Code of 1884, has had the opportunity to know of several cases that prove the foregoing statement, but in this paper, already too long and tedious, it would not be advisable to recite them.

It is sufficient to say that the actions provoked by denouncements for abandonment were frequent and lengthy, and came from the difficulty of proving whether the mine really was abandoned or not. The same could be said concerning questions of the subterranean invasion of *pertenencias*, even when permitted, more frequently than not; the provisions for such cases of the Code of Mining were not complied with. For similar reasons the questions of drainage were prolific of contentions. Notwithstanding that the Code of 1884, like the Ordinances of Mining, established compulsory working in the mines as the only means of preserving the property in them, there were not wanting means for the miner to retain this property without doing any work and still keep within the bounds of the law. By combining and alternating the periods of abandonment and protection (*amparo*) that could be granted by the Deputations of Mining and by the Minister of *Fomento*, he could arrange to work only six months in three years, or he

could even allow the denouncement to become forfeited and, as the law did not prohibit it, make a new denouncement. By such means he could retain the property of a mine without ever doing any work. Several Deputations of Mining reported cases where miners had held mines by these means for five and six years without ever taking possession.

After the promulgation of the Mining Code various circulars were issued, of which I shall cite only the principal ones: that of 13th July, 1886, elucidating Articles 50 and 57, with regard to the date from which the period of abandonment should begin to be computed; that of 5th October, 1886, explaining Article 112, relating to the adjudication of *demasías* (unoccupied ground between two concessions) less than a *pertenencia* in extent; that of 24th June, 1887, establishing regulations under Articles 112 and 123, as to the inspection of mines; and that of 25th September, 1889, explaining Articles 117 and 118, as to communications between contiguous mines.

The mining industry had scarcely begun to feel the influence of the Mining Code, just issued, when it was threatened by a new danger in the strong and sudden depreciation of silver. The Government considered that the advantages offered by the Mining Code were not sufficient to tide over the crisis, and, moreover, that it was necessary to proceed with activity, employing energetic and efficacious means to counteract the evil. The Department of *Fomento* immediately proceeded to work on this line, and, comprehending perfectly what were the most important points to be studied in order to solve the question, appointed a commission, composed of the Engineers D. Gilberto Crespo y Martínez and D. Augustín Barroso, to make a study of the probable causes of the mercantile crisis and of the depreciation of silver, and to indicate the measures that, in their opinion, it would be wise to take.

Another commission, composed of the Engineers D. Manuel María Contreras and Andrés Aldasero, was appointed to report concerning the influence of the depreciation of silver on our mining industries, and the practical means of promoting this industry in order to reduce the cost of production.

Engineer D. Luis Salazar was commissioned to study what agricultural products should be fostered by the Federal Government, and in what manner; Sr. Francisco Bulnes and Dr.

Manuel Flores to propose the means for the development of the industries existing in the country, and those that could be undertaken with good prospects of success; and Lawyer Joaquín D. Casasús to indicate whether or no it would be advantageous to the Republic to enter into some international monetary agreement.*

All these commissions satisfactorily discharged their prescribed duties.

By determination of the President of the Republic, communicated through the Department of *Fomento*, the Departments of the Treasury and of *Gobernación* were invited to appoint delegates who, together with the delegate of the Department of *Fomento*, should make a complete study of the matter and formulate the reforms that ought to be made in the customs duties in order to promote agriculture, mining and industries in general. The result of all this work was the bill that several members of the Parliament presented to the Chambers, and which, with slight modifications and after mature discussion, was approved and promulgated under date of 6th June, 1887.

By this law, mines of coal, in all its varieties, of petroleum, of iron and quicksilver, and also their mineral products, were exempted from all Federal, local or municipal tax, except the stamp-tax. The circulation, within the Republic, of gold and silver, either in bullion or coined, and of the other metals and of all products of the mines, was declared free from the duties of *octroi* (*alcabala*) or of porterage, and from all tax. Quicksilver, of whatever origin, was exempted from all charges, whatever might be their denomination.

As for taxes: One alone was decreed for mines, and that was 2 per cent. on the value of the metal, or of the substance exploited, without deduction of costs; and for reduction-works 6 per M. on the value of the property, with all its machinery, was the only tax. Any other tax, under whatever name it might be known, was strictly prohibited, and the States, also, were prohibited from collecting dues for denouncements, possessions, and other formalities for the acquisition of mines and reduction-works.

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* La Crisis Monetaria.

By Article 10 of this law the Executive was authorized to enter into contracts for mining explorations and exploitations, granting special franchises and ample concessions, being subject in the closing of the contracts to the following conditions:

The duration of the special concessions and franchises could not exceed ten years; the minimum of capital that might be invested in the exploitation of mines should be $200,000 within five years; this capital should be exempt from all Federal tax except the stamp-tax. The maximum number of *pertenencias* that could be granted in common cases was twenty, either continuous or separated, and thirty, when treating of the discovery or restoration of Mining Districts. The dimensions of *pertenencias* were subject to the prescriptions of the Mining Code of 1884, except in the case of auriferous placers. In this case the *pertenencias* were considered the same as those for an irregular mineral-deposit [300 m. x 300 m. The *pertenencia* on gold-placers was, by the Code, 20 meters on a side]. The number of operatives that a concessionaire could have would be twenty, the company having the most ample freedom to work in the *pertenencia* or *pertenencias* that it might wish. Moreover, the Department of *Fomento*, in grave cases, properly authenticated, could grant an extraordinary protection (*amparo*) up to two years; the concessionaire could also enjoy the protections to which the Mining Code referred.

Such were the principal dispositions with respect to mining established by the law of 6th June, 1887. It also contained others applicable to other industries. The Department of *Fomento*, in virtue of the powers granted in Article 10 of the law of 6th June, 1887, entered into 366 contracts with distinct individuals for mining explorations and exploitations.

By this means it obtained the investment of a large amount of capital, not only in the exploitation of mines, but also in the reconnoissance of a great part of the States. Mining-production augmented notably, notwithstanding the monetary crisis that threatened to restrict its production.

Besides the law of 6th June, 1887, of which we have been speaking, a decree was issued on the same date authorizing the Executive to acquire, by purchase, a process of reduction that should satisfy certain conditions, and to grant franchises and privileges to the company owning the process.

V.

The Law of 4th June, 1892, *and Circulars Relative Thereto.*

The passage from the Ordinances of Mining to the legislation of the States, the passage from this to the Mining Code of 1884, and from this to the law of 6th June, 1887, provided useful lessons and great experience, which gave ability to appreciate what was the path that ought to be followed to give stability to mining-property, and to guarantee its rapid and certain development.

Señor D. Manuel Fernández Leal, Engineer, who, through great and recognized merits, had reached the honorable position of Secretary of *Fomento*, fully understood this, and in an important memorial to the Congress of the Union on the condition of the different bureaus of the department so ably administered by him during the four years 1892–96, expresses himself thus:

"Starting from the principle demonstrated by the facts of modern science, as also by the reasoning of the most profound thinkers, that property, whether mining or any other, is productive only when easy to be acquired and certain to be preserved, and that its exploitation should be free and voluntary; this Department has aspired for some time to assimilate, as much as possible, mining-property to other forms of property, to cover it with the shield that protects not only territorial but personal and even intellectual property, and to put in its hands the supplement of resources that these guarantees provide for its extension and betterment."

To this end were directed the noble endeavors of the Secretary of *Fomento*, efficiently aided by his sub-Secretary, the learned and progressive Engineer, D. Gilberto Crespo y Martínez. Inspired by these motives, after mature and careful study, the Secretary of *Fomento* presented to the Chambers his draught of a law, expressing himself as follows:

"Now that the country enjoys perfect tranquillity, realizing slow but certain progress in the most important branches; that means of transportation begin to be easy and economical; that all industries respond to these favorable conditions; that the currents of traffic are modified, commerce is transformed and crises produce less lamentable effects than in epochs not far distant, it seems apparent that, when in virtue of all these circumstances our social condition is bettered and the wealth of the nation augmented, we should consider the most opportune moment has arrived to implant a fitting reform in our laws which, if indeed they define it well, very imperfectly protect, the property of mines."

Farther on:

"If the great economic laws of labor are exact, there being no reason allowing us to suppose that they can vary in their results by their application to the exploitation of substances found beneath and not above the surface of the ground, it is indubitable that the rapid aggrandizement of Mexican mining will be accomplished by these three conditions: facility of acquisition, liberty of exploitation, security of retention."

This initiative, amply and minutely discussed in the Chambers, was approved and the law issued, under date of 4th June, 1892, which consolidated mining-property and placed it upon almost the same footing as other properties.

According to this law the miner can acquire the number of *pertenencias* he wishes, whether continuous or broken (interrupted),—a *pertenencia* being defined as a square, 100 meters long on each side. He is given complete liberty of industrial action to work in the manner that best suits his convenience, to push forward (*activando*), retard or suspend, for more or less time, his works; to employ in them the number of operatives he wishes, and at the point that appears to him the best, and follow the system he prefers of working, extraction, drainage and ventilation, as he judges most appropriate to his own interests. Nevertheless, he is held responsible for the accidents which happen in the mines, on account of being badly worked, and must "indemnify the damages he may cause other properties by want of drainage or any other circumstance that diminish alien interests." (Art. 22 of the Law.)

The unclaimed lands (*demasías*) between two or more adjacent mines are no longer divided between them, as was formerly the practice, but they are given to whoever solicits them first. The miner can no longer go outside of the boundaries of his own *pertenencia* and enter that of his neighbor without the latter's consent. Works of possession were suppressed since this formality had been abolished. Now, the property is acquired by the title issued by the Department of *Fomento*, and is irrevocable and perpetual on the payment of the Federal property-tax, and is lost only through failure to make this payment. Mining-lands, as well as adjacent ordinary properties, are subject to the easements of passage, aqueduct, drainage and ventilation. Lastly, mining-works are declared to be of "public utility," and, in consequence, the land necessary for

them can be obtained by expropriation in default of a mutual agreement between the parties concerned.

The Deputations of Mining were abolished, and in their place were substituted Agencies, of which there are 140 dispersed throughout the Republic in such manner as is considered most conducive to the proper dispatch of business relating to the mines.

The Mining-Agents have no other functions than to give legal course to the petitions for concessions presented to them in accordance with the Regulations issued under the law of 25th June, 1892.

The first steps of the proceeding having been taken and the papers drawn up, they are remitted to the Department of *Fomento* and, after examination, if approved, the title issues. In case any opposition is presented to the action of the Agent, and it is impossible for the parties to reach an agreement, the matter is referred to the Courts. The fees to be paid the Agents for the discharge of their duties are fixed by law.

Various circulars have been issued since the law of 4th June, 1892, of which I shall cite only the principal ones.

No. 3 refers to the amplification or reduction of *pertenencias;* No. 4 to the retirement of the petitioners after the petition for concession has been admitted by the Mining Agencies. No. 11 treats of the manner of procedure when petitioning for amplification, rectification or reduction of mining-property. No. 12 treats of the legal procedures when a foreigner petitions to acquire mining-property within the frontier-zones of twenty leagues. No 30 treats of the reduction of *pertenencias* and the voluntary retirement of those interested. No. 32 makes more clear and precise the conditions which, by the Regulations under the law of 4th June, 1892, the petitions for concessions should satisfy, in order to be admitted. No. 33 fixes the penalties incurred by those interested, who, when they receive the document of proceedings, or a copy of it, do not deliver it to the Judge or the Department of *Fomento* (as the case may be) within the time designated by the Agency.

The law of 6th June, 1892, established the Federal property-tax to which the mining-law refers. It is divided into two parts: one is satisfied by revenue-stamps, which are affixed to the titles, and is paid only once; the other is paid annually on

each *pertenencia* of which the concession is composed. According to the law cited, the stamps to be affixed to the titles are of the value of $10 for each *pertenencia* or fraction equal to or greater than one-half; fractions less than one-half are not taxed. The annual tax is also $10 for each *pertenencia*, to be prepaid in thirds every fiscal year. The Regulations under this law, dated 30th June, 1892, fix the basis for the payment of this annual tax, the mines covered by contract with the Department of *Fomento* having been exempted.

The foregoing tax was modified by the Decree of 3d June, 1898; according to this, titles to mines which are not of gold, silver or platinum require stamps for only $2.50 per *pertenencia*, and the annual tax is reduced to the same amount. But if these mines contain gold, silver or platinum, in whatever proportion, they shall pay the quota of $10 per *pertenencia* both on the titles and in the annual tax. The Executive, in this case, can reduce the annual tax to $5 per *hectara*, if the *pertenencias* of one Company are over 50 and less than 100, and to $2.50 if they are over 100; provided, always, that the ores contain less than 250 grammes of silver or less than 10 grammes of gold per ton. Various other decrees were issued since the laws of 4th and 6th June, 1892.

Articles 1 to 5, inclusive, of the Decree of 31st October, 1892, have now become of no effect; there remains in force only Article 6, authorizing the Executive to make such modifications in the laws of 4th and 6th June, 1892, as he believes necessary for the betterment and development of the mining industry. The Decrees of 31st December, 1892, and 6th June, 1894, having served their purpose, are now without application.

The Decree of 14th December, 1897, declares that, upon the termination of a permission for exploration, granted under the Mining Law and its Regulations, no new permission shall be given to explore the same ground until six months have elapsed. During this time the ground remains open to petitions for mining-grants. The same Decree declares that, where there are mines in possession, the explorations shall be conducted only in lands that are 200 meters from the boundaries of the *pertenencias*. It also permits explorations in abandoned mines.

The Decree of 13th November, 1899,—the last one relating to mining that has been issued—extends to one year the time granted for explorations when dealing with subterranean auriferous placers. These explorations, however, are no impediment to the solicitation of grants under the ruling law, to exploit deposits of any other minerals within the zone of explorations.

In the present year, several circulars have been issued, among which it is necessary to mention only No. 34, since the others directed to the mining-agents are economic in character, and have for their sole object the greater improvement of the service.

Circular 34 recalls to notice the fact that the reduction of the *pertenencia*, for which petition has been presented to the Agencies, can be accomplished only during the course of the proceedings, or after the acquisition of the respective title.

Here end the dispositions that have been given, up to the present, concerning mining in this country, and by this lengthy account can be seen the different transformations that mining legislation has undergone (without change of principles) from the Colonial times to the issuance of the law of 4th June, 1892.

With the promulgation of this law, principles entirely the opposite of those which had been in force for more than a century were established, and, therefore, it is easy to understand the commotion that took place in the guild of miners with such a radical change, especially since it was believed that those principles were the only ones proper for the mining industry. This belief was deep-rooted, since it had been almost unquestioned for centuries. Clubs, Congresses, Juntas and Commissions were formed among the miners to protest against the law, but the Supreme Government, convinced that it had not yet been well understood, believed it best to wait; and now, be it said to their honor, these very opposers of the law are the very ones, the first, who do not wish to return to the old régime.

At first, dissatisfaction was noticed on all sides; no one approached the Agencies to solicit mining *pertenencias*, or, in case petitions were presented, they were only for one, or at

most two, *pertenencias*. Time passed, convincement came, confidence reigned, prejudices disappeared, and ideas changed, with the result that the movement in mining became so much greater that I do not hesitate to say that the present epoch is the most favorable for mining that Mexico has ever experienced.

In the most interesting memoir, published by the Minister of *Fomento*, Engineer Sr. D. Manuel Fernández Leal, and which refers to the quadrennial 1892 to 1896 (part of the time that this Department was under his charge), can be seen what has been the result of the law of which we have just spoken.

VI.

Conclusion.

By what has been set forth in the foregoing pages, it is easy to see that mining-property in Mexico has been subject, during the lapse of time, to all the different systems that have governed property in mines. Of all these, which has been the most appropriate for Mexico? This is not a question for me to solve; I lack completely the necessary aptitudes and knowledge, and it was not for this that I was honored by the invitation to prepare this paper.

Furthermore, the question, in my judgment, is difficult when we take into account the conditions of peace, tranquillity and progress that we now enjoy and which did not exist in former times. Since these conditions intervene as a most essential factor in the problem, it is easy to comprehend how difficult it is to arrive at an exact conclusion.

It can be objected that the progress of the country, which is greater every day, implies as a necessary consequence advance in all the other distinct branches; this provokes these questions: Is the law of 4th June, 1892, now actually in force, in proper relation with the advance and progress achieved by the country? Is the prosperous state which our mining enjoys at present due principally to the present legislation or to the conditions of advance, peace and tranquillity that we enjoy, or to both causes combined? The foregoing considerations have been suggested to me by the opinions that have been presented for and against both the present and the former legislation.

Believing that the data relating to production should be taken into account in the study of this question, I give them in the following statement.

The production of silver and gold, as shown by the coinage-value, was:*

Colonial Legislation.

Silver and Gold.	Production.	Annual mean.	Difference
1492 to 1881, . .	$4,553,859,113	$11,828,205	———

State Legislation.

Silver.	Production.	Annual mean.	Difference.
1881 to 1885, . .	$157,827,478	$31,565,495	$19,737,290

Code of 1884 *and Law of* 6*th June*, 1887.

Silver.	Production.	Annual mean.	Difference.
1886 to 1890, . .	$199,208,204	$39,841,640	$8,276,145

Law of Consolidation.

Silver.	Production.	Annual mean.	Difference.
1892 to 1896, . .	$225,247,495	$56,311,864	$16,470,224

As is seen, in the production from 1881 to 1890, silver only has been included; the production of gold was as follows:

Years.	Production of Gold.
1892–1893, ...	$1,269,907
1893–1894, ...	1,244,621
1894–1895, ...	4,744,542
1895–1896, ...	6,054,078†

With great satisfaction, I give the value of the production of silver and gold from 1st July, 1896, to 30th June, 1901, as follows, according to the data kindly furnished by the present Director of Mints, Engineer Sr. D. Manuel Fernández Leal, to whom I am under great obligations for his kindness, attention and assistance. These data have been calculated from the deposits in the Mints, the exports reported to the Mints, and the export reported to the Custom Houses.

Fiscal Years.	Value of Silver.	Value of Gold.
1896–1897, . .	$63,342,454.70	$7,218,835.93
1897–1898, . .	70,923,024.53	7,726,005.99
1898–1899, . .	69,547,708.11	8,339,891.83
1899–1900, . .	72,115,508.36	8,505,787.04
1900–1901, . .	74,245,907.87	10,056,350.77

* The foregoing data have been compiled by combining those of the *Riqueza Minera de Mexico*, by D. Santiago Ramírez, with those of the *Memoir of Fomento* for the four years, 1892 to 1896.

† *Memoir of the Ministry of Fomento*, 1892 to 1896, p. 75, published by the former Minister, Engineer Sr. D. Manuel Fernândez Leal.

*Total Value of the Production of Silver and Gold.**

Fiscal Years.	Value of Silver and Gold.
1896–1897,	$70,561,290.63
1897–1898,	78,649,030.52
1898–1899,	77,887,599.94
1899–1900,	80,621,295.40
1900–1901,	84,302,258.64

Unfortunately, I do not have the production of copper, lead, iron, etc.; but the foregoing data, always increasing, demonstrate among other things that, notwithstanding the great depreciation of silver, mining in Mexico has not gone backward, but has rather acquired greater development, and this is more noticeable since the passage of the law of 4th June, 1892. The great economist, Leroy Beaulieu, says that:

"The best mining legislation is that which assures to the exploiters the greatest security in possession and the most freedom; property in mines should be irrevocable and perpetual in the hands of the private persons who have carried on the explorations. Exploitation by the proprietors should not be compulsory; this will induce them either to abandon the investigation of mines or to the wasteful mismanagement of mineral-deposits, of which it is necessary that a nation should always have an abundant known reserve."

The law of 4th June, 1892, is founded, as has been seen, on these very principles, and the results obtained can already be appreciated.

I here end this paper with great regret for my inadequate response to the honor conferred upon me by the invitation to prepare it. And I can only beg the honorable Minister who thus distinguished me, not to doubt for a moment my lack of endeavor—this has not been wanting. The cause of the incompleteness of the work has been only my own incompetence and the limited time at my disposal.

* The value of the gold is expressed in Mexican money, the legal value of a kilogramme being, as is known, equal to $675,416.

The Sierra Mojada, Coahuila, Mexico, and its Ore-Deposits.

Discussion of the Paper of James W. Malcolmson (see p. 100).

(Mexican Meeting, November, 1901.)

S. F. EMMONS, Washington, D. C.: Mr. Malcolmson's paper on the intensely interesting deposits of the Sierra Mojada creates a strong desire to visit the region so well described. Although it is difficult to intelligently discuss a locality that one has never seen, I cannot refrain from offering some remarks in the nature of a tentative suggestion:

1. *Age of Beds.*—Mr. Malcolmson speaks of the enormous thickness of limestone forming the Sierra Mojada as belonging to the Carboniferous series. If this is not a typographical error, it seems that he should present some evidence for such age, for Chism,* in his previous article on the district, says the only fossils found there were said to be Cretaceous; and it is well known by the investigations of R. T. Hill and others that the great thickness of limestone in this part of Mexico is of Cretaceous age.

2. *Structure of Mountains.*—Mr. Malcolmson presents good reasons for thinking that the structure of the two related mountain masses (Sierra Mojada and Sierra Planchada) is not the simple anticlinal fold given by Mr. Chism's section, it being evident that there has been faulting as well as flexure.

I venture to add that the facts presented by Mr. Malcolmson seem to suggest the possibility that, instead of being simply an eroded anticline, the valley between the two ranges may have been formed, in part at least, by the irregular faulting down of the intermediate block, on the surface of which the volcanic breccia had originally accumulated at a higher level. The sections of the Exploradora and the San José mines, in the smooth surface of the contact, with clay selvages and the occasional slickensides, certainly suggest a structural fault between the limestone and breccia. The arrangement of some of the

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* *Trans.*, xv., 542.

ore-bodies on lines parallel with the contact offers the same suggestion.

The existence of faults in the limestone at right-angles to this contact is quite in consonance with this hypothesis. These phenomena and the distribution of the ore-bodies resemble the manner of the occurrence of the ore and limestone on one side of the great fault-fissure in the Globe district of Arizona.

It is more difficult, it is true, to account for the nearly horizontal position of the contact in the Dionea and other mines; but these are at some distance out from the vertical cliffs which would approximately correspond with the steeper part of the fault-plane. In the great landslip areas in the San Juan mountains, near Telluride, Colo., Mr. Cross has shown that, where masses several miles in extent have slipped down from the sides of the mountains, the plane of movement is a curved surface passing from a vertical nearly to a horizontal position. And it seems possible that in the Sierra Mojada the faulting may also have been in the nature of a landslip, though of much more ancient date and obscured by subsequent geological action.

3. *Distribution of the Ores.*—In the alteration of sulphides to oxides and carbonates, especially where the alteration is so thorough and deep-seated as it is in arid regions like Mexico, there is apt to be much actual migration and redistribution of the material during the process. This fact is evidently recognized by Mr. Malcolmson, though he does not discuss it in as much detail as could be wished.

This secondary migration is likely to be more or less proportional to the relative solubility of the sulphates of the respective minerals; thus the lead would have moved but little from its original position, the silver more, and the copper and zinc most of all. Hence, the lime impregnated by silver chlorides beneath the lead-deposits, described by Mr. Malcolmson, seems quite normal. The contact-deposits of copper-ore in the San José mine, in being placed above the lead- and silver-deposits, would appear to be in abnormal conditions. It is possible that they may be the product of the leaching of some overlying pyritous deposits now eroded away. A detailed study of these deposits from the point of view of secondary migrations would be extremely interesting, and probably Mr. Malcolmson may be able to add something in this line to his already valuable paper.

Gems and Precious Stones of Mexico.

Discussion of the Paper of George F. Kunz (see p. 55).

(Mexican Meeting, November, 1901.)

EDWARD HALSE, Puerto Berrio, Colombia, S. A. (communication to the Secretary): I have read with much pleasure the interesting and valuable paper by Mr. Kunz, and hope that the following brief notes, gathered a few years ago, while a resident in Mexico City, may help to elucidate the subject:

Turquoise.—This was known to the Aztecs as *Xihuitl.* Santiago Ramirez states that they found it in the Cerro Xicohtzonc, close to Atzcapatzalco, a suburb of the City of Mexico (compare page 59).

Opal.—This was known to the ancient Mexicans, for they named it *Mezcuitlatl* (compare page 63).

Jade.—Under this was included a third mineral, prehnite, not mentioned by Mr. Kunz. According to James D. Dana, part of the "jade" of China is prehnite; and Humboldt informs us, in his work on New Spain, that the same species of jade is known in some parts of Mexico as *mahagua* (*majagua ?*). The same writer says, in his *Views of the Cordilleras*, that the Aztec name *Tecpatl* included flint, hornstone, and green jade; and finally, in his *Travels in South America*,* he discusses the nature of the *ancient* amazon-stones, and declares them to have been made out of a jade resembling "compact feldspar," one of the constituents of the gabbro *verde di Corsica.* Hence those stones were probably composed of nephrite. According to Humboldt, the form given to them most frequently is that of the Babylonian cylinder, longitudinally perforated, and loaded with inscriptions and figures. They were also cut by the natives into very thin plates, perforated at the center, suspended by a thread, and worn as amulets.

According to the historian Clavijero, the specific name given by the Aztecs to the nephritic stone (jadeite) was *Quitzalitztli*,

* Edition of T. Ross, London, 1881, vol. ii., pp. 395–399.

although, undoubtedly, as Mr. Kunz has shown, it was included, among other green stones, in the more general term *Chalchihuitl* (the *Chalchuites* of Prescott).

Obsidian.—Mr. Kunz says this name is a *nahuatl*, or aboriginal Mexican one. But the word is clearly not of Mexican origin. Cæsalpinus derives it from Obsidius, a Roman, who first brought it from Africa. Clavijero gives, as the Aztec name for obsidian, *Itztli*, sometimes written *Itztle*, and, in some States of the Republic, *Ixtete.* According to Orosco y Berra, it is the *Tzinapu* of the Tarascans; and, it may be added, is identical with the *Esponja* of the Incas.

Santiago Ramirez names the following varieties of this rock: *obsidiana dorada; o. plateada* or *argentina; o. negra; o. azulada; o. verde; o. roja* or *de Pénjamo.* The last was much prized by the ancient Mexicans, as fragments of it are found in their *coesillos*, or tombs.

Ezequiel Ordoñez* describes two petrological varieties of obsidian, one trachytic and the other perlitic. The former is rare, and the latter may be confounded, at first sight, with the trachytes (*chiluca*) of Los Remedios.

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* *Boletin del Instituto Geológico de Mexico*, No. 2. "Las rocas eruptivas del S. O. de la Cuenca de Mexico," Mexico, 1895, p. 41.

A

GLOSSARY

OF

SPANISH-AMERICAN MINING AND METALLURGICAL TERMS

COMPILED BY

ARTHUR S. DWIGHT

San Luis Potosí

Mexico

Assisted by Many Members of the American Institute of Mining Engineers

PUBLISHED BY THE INSTITUTE

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INTRODUCTION.

THE labor of compiling this Glossary was undertaken at the request of the Secretary of the Institute, for the purpose of appropriately supplementing the literature called forth by the visit of the Institute to Mexico. To this end, a circular letter was addressed to all members of the Institute, requesting the contribution of Mexican or Spanish mining and metallurgical terms, and a sufficient number of responses were received to make it possible to prepare a "Preliminary Proof Edition" in time for distribution at the Mexico Meeting. As this had to go to press without proper revision or proof-correction, it is not surprising that it contained many errors. Most of these, it is hoped, have now been eliminated, while about six hundred definitions have been added.

There is no doubt that the list can be considerably increased with advantage, and supplementary lists may possibly be issued from time to time in which shall appear additional terms and corrections based upon further contributions and criticism by competent persons. That there is a large and increasing number of technical men in professional or commercial relations with Spanish-speaking countries who would appreciate a good technical glossary, there can be no doubt.

The compiler lays no claim to authority as a lexicographer, but the editorial work of selection, simplification and condensation has been performed conscientiously in the face of many inconsistencies in the matter contributed. All doubtful questions have been settled according to the judgment of the compiler, after consulting all published authorities at hand, and aided by the friendly counsel of Mexican engineers. Some of these decisions may, however, be subject to further discussion and revision.

It will be noticed that mining terms are more largely represented than metallurgical. This is accounted for by the fact that while Mexican mining methods and corresponding technical terms have, to a large extent, retained their existence and individuality, the ancient processes of reduction, with the marked exception of the *patio* process of amalgamation, have been so largely displaced in recent years by American methods as to make, in most cases, the technical terms of present practice simply obvious translations, more or less felicitous, of their English synonyms. Such self-explanatory terms have been generally omitted.

Many mining terms have different meanings in different districts of Mexico, but it has been thought best not to attempt to specialize too closely, and in a few instances only have Mexican localities been indicated. The rapid growth of the railroad systems will soon obliterate these differences, and the most convenient terms will survive.

This being essentially a Glossary of Mexican Terms, all those defined may be presumed to be in use in Mexico, unless accompanied by a special designation, as Spanish (Sp.) or (Peru). The latter sign is attached to many Peru-

vian words contributed by Mr. Otto F. Pfordte, while the former refers to a number of terms well-authenticated as to general use in technical literature but not positively known to be current in Mexico.

The Spanish alphabet recognizes "ch" as a distinct character, but as it is somewhat more convenient to English readers to use the same sequence of letters as in English, this liberty has been taken in the arrangement of the Glossary, following the respectable precedent of the well-known Velazquez *Spanish and English Dictionary.*

"Ll" and "ñ" are, however, treated as separate characters.

To repeat the rules for pronunciation and the use of the accent mark, seems hardly necessary in a work of this kind; but, as there actually is some disagreement among authorities as to the use of the accent, it may be proper to state that the procedure followed in this Glossary is in accordance with Wm. I. Knapp's *Spanish Grammar*, Boston, 1900.

The list of those who have rendered assistance in this work comprises:

Richard E. Chism, Mexico City; A. W. Jenks, Mapimí, Durango; Bertel Peterson, Torres, Sonora; Charles H. McMahan, Sombrerete, Zacatecas; Otto F. Pfordte, Rutherford, N. J.; Gustav Thorkildsen, Mexico City; Edward C. Knight, Monterey, Nuevo León; W. B. A. Dingwall, Matehuala, San Luis Potosí; Edmund Girault, Mexico City; E. D. Self, Linares, Nuevo León; John Gross, Sombrerete, Zacatecas; Eugene A. H. Tays, San José de Gracia, Sinaloa; Carlos Riedt, Mapimí, Durango; Roberto Ipiña, San Luis Potosí; J. D. Robertson, Coalcomán, Michoacán; Juan C. Rodriguez, Saltillo, Coahuila; Adolfo Martínez, San Luis Potosí; Henry F. Collins, London; John A. Church, New York City; Caspar Wistar Haines, Richmond, Va. To these names that of Mr. Carlos F. de Landero, of Pachuca, Mex., a Vice-President of the Institute, should be added with special acknowledgment of his generous aid in the revision of the Glossary.

Published works consulted:

1. Apuntes de Minería en forma de Diccionario para el Minero Práctico. Felix Nieto, Zacatecas, 1891.

2. Dictionary of Terms, English, German, Spanish, French. Max Venator, Leipzig, 1897.

3. Technological Dictionary. Ponce de León, New York, 1893.

4. Glossary of Mining and Metallurgical Terms. R. W. Raymond, New York, 1881.

GLOSSARY.

Abaco. A stone trough used to wash minerals.

Abajador. The workman in charge of tools furnished to miners underground.

Abigarrado. Variegated in color (applied to minerals).

Abra. Open fissure or cavity in the rocks.

Abrazador. Clip.

Abridura. Enlargement of a space, so that miners may work freely.

Abrigo. The width of a vein.

Abronzado. Chalcopyrite.

Acarreo. Transportation; hoisting.

Acarreos. Float-rock.

Accion. Share in a mine, or other enterprise, usually 100 to the *barra*. Right or ground of action in a suit.

Accionista. Shareholder.

Aceitera. Oil-cup.

Acendrar (PERU). To refine.

Acequia. Canal or ditch.

Acerado. Gray copper-ore. Any gray steely ore.

Acero. Steel. ——**colado.** Cast steel.

Achaparerera. Long-handled adze.

Achicador, or **Achichinque.** Carrier of water. (See *Achicar.*)

Achicar. To remove water from a mine, generally by carrying it out in bags or buckets.

Ácido. Acid.

Acomodana (PERU). Ore-deposit.

Acre. An acre. Sour.

Activar. To quicken the chemical reactions in the *torta*.

Acueducto. Aqueduct.

Acullico (PERU). Resting-hour.

Acuñar. To coin. To wedge.

Acuoso. Watery.

Adarme. A weight for gold and silver, about 1.8 grammes. Pennyweight.

Ademador. Timberman.

Ademar. To timber.

Ademe. Timber in mines. Timbering in general.

Administrador. Manager of a mine.

Adobe. Sun-dried brick.

Afiladera. Whetstone.

Afilar. To sharpen (tools).

Afinación. Art or process of refining. Refining works.

Afinador. Refiner.

Afinar. To refine.

Aflojadero. Soft part of a vein.

Afloramiento. Outcrop of vein.

Afrechera (PERU). Finely-divided amalgam produced with insufficent mercury.

Agachadero. Place in a level, where roof is low.

Agrimensor. Surveyor.

Agua. Water. ——**fuerte.** Nitric acid.

Aguja magnética. Magnetic needle.

Agujero. Drill-hole.

Agujón. Surveying-instrument with compass.

Aguzar. To sharpen (drills).

Ahondar. To sink.

Ahonde. A shaft to establish mining title.

Aire. Air.

Ajuste. Contract; Adjustment (of parts of a machine).

Ala de mosca (PERU). Granite or very hard rock.

Alajites. Altered rhodonite.

Alambre. Wire.

Alarife (SP). Mine mason.

Albañil. Mason.
Albayalde. White lead.
Álcali. Alkali.
Alcance. Balance due.
Alcancía. Loading-chute.
Alcantarilla. Culvert.
Alcaparra, or **Alcaparrosa.** Efflorescence (of sulphates, etc.) in old workings.
Alcarraza. Water-can used in drilling.
Alcribis. Tuyere. (See also *Tobera.*)
Alear. To alloy.
Alimentador. Ore-feeder.
Alipús. Gad.
Almacén. Warehouse.
Almadeneta. Stamp-head or shoe.
Almagre. Red ocher.
Almártaga (PERU). Litharge.
Alquitrán mineral. (See *Betun.*)
Alsa (PERU). Roof of underground level, gallery, etc.
Alto. High. Hanging-wall. (See also *Respaldo.*)
Altura. Height; altitude.
Aludel (SP.). Earthen condenser for mercury.
Alumbre. Alum.
Aluvión. Alluvium.
Alzador. Workman employed in loading wagons, etc.
Amalgama. Amalgam.
Amalgamar. To amalgamate.
Amatista. Amethyst
Ámbar. Amber.
Amianto. (See *Asbesto.*) Asbestos.
Amojonar. To set monuments or landmarks.
Amoníaco. Ammonia.
Amorfo. Amorphous.
Amparar. To cover (title).
Ampliaciòn. The enlargement of a mining claim.
Ampollosa. Rock structure, containing cavities.
Analizar. To analyze.
Ancla. Anchor; hook.
Ancon de tierra. Projecting or salient corner of a claim.
Andamio. Builder's jack. Scaffold.
Andén. A path for horses around the shaft. RR. station platform.
Andesita. Andesite.
Anegada. Drowned. Overflowed. Left to fill with water.
Ángulo. Angle.
Anillo. Ring; collar; loop on the end of a rope.
Anillos. Set of shaft-timbers; shells for crushing-rolls.
Anodo. Anode.
Anquería (PERU). Silver-ore looking like cubical galena.
Anquerita. Ankerite.
Antimonio. Antimony. —— **blanco.** Valentinite. —— **rojo.** Kermesite.
Antracita. Anthracite.
Apagar (un horno). Blow out a furnace.
Apalancar. To move with a lever.
Aparador. Re-worker of tailings from silver mills.
Aparato. Apparatus.
Aparejo. Pack-saddle. Any rough apparatus for moving heavy timbers, etc.
Apartado. Ore-separation or concentration. Parting gold and silver. The place where this work is performed.
Apartador. Hand-sorter of ore.
Apelmazado. Compressed ground.
Aperador. Store-keeper.
Aperos. Mining supplies.
Á pique. Vertical.
Apique. Shaft.
Apires (PERU). Ore-carriers in mines.
Aplanador. Blacksmith's flatter.
Apolvillados. Ores of superior grade.
Arcilla. Clay.
Arcilloso. Argillaceous.
Área. A square of 10 meters.
Arena. Sand.
Arenillas. Tailings; refuse earth. Sand-carbonates.
Arenisca. Sandstone.
Arenoso. Sandy.

Argamasa. Lime mortar.
Arista. The intersection-line of two planes.
Armar. To erect or fit up machinery, etc.
Armazón, Armadura. Any framed structure, truss, trestle, etc.
Arrastrador. Slag-pot puller.
Arrastrar. To drag along the ground.
Arrastrar el agua. To almost completely unwater a working.
Arrastre. A circular trough in which drags are pulled around for grinding and amalgamating ores. —— **de cuchara.** Arrastre driven by rough impact water-wheel, the blades of which are called "cucharas." —— **de marca.** Large arrastre. —— **de mula.** Mule-power arrastre.
Arreador. The mule-driver on a hoisting-whim.
Arrebol. The jerking of a rope as a signal to miners underground.
Arriero. Muleteer.
Arriñonada. Botryoidal.
Arroba. Twenty-five pounds.
Arroyo. Gulch. Small stream.
Arsénico. Arsenic.
Asbesto. (See *Amianto*). Asbestos.
Asentador. Settler.
Aserrar. To saw.
Asfalto. Asphalt.
Asiento. The concentrate in panning.
Asiento mineral. Mineral region.
Aspa (PERU). Intersection or junction of two veins. Certain timbers used in mines or mills.
Asperón. Sandstone. Grindstone.
Aspirador. Exhauster.
Asta-bandera. Flag-staff.
Atacador. Tamping-bar.
Atacar. To tamp (PERU). To express mercury from a canvas bag by beating it with a stick.
Atajo. Trail.
Ataques. Rubbish.
Atecas. (See *Achicadores.*)
Atierres. Waste-rock and dirt in a mine.
Atincar. Borax.
Atizador. Stoke-bar; poker.
Atrancar. To drill (for blasting) at a very acute angle.
Aturdir. To subdivide, mechanically, the quicksilver in a *torta* so as to quicken its action upon the mineral treated.
Auquis (PERU). Rock-drillers in mines.
Aurífero. Gold-bearing.
Avena. Oats.
Aviador. Furnisher of funds to work a mine.
Avío. Money furnished by an *Aviador.*
Ayate. Coarse fiber-cloth for carrying ore, dirt, etc.
Ayuda. A small bonus to tributers who fail to make expenses. **Metales de** ——. In smelting, lead-ores.
Ayudante. Assistant.
Ayunque (or **Yunque**). Anvil.
Azabache. Jet.
Azarcon nativo. Minium.
Azimut. Azimuth-bearing.
Azogado. Poisoned by mercury.
Azogue. Quicksilver.
Azoguería. Amalgamation. A storehouse for quicksilver.
Azoguero. The "mud-chemist" (also, the metallurgical foreman) in a patio-works.
Azogues. Free-milling ores. Common name for third-class silver-ore, generally carrying 35 to 150 oz. per ton, which will pay for mining and shipping.
Azuela. Adze.
Azufrados (PERU). Sulphide-ores.
Azufre. Sulphur.
Azufrones. Sulphide ores.
Azulaques. Finely disseminated ore. An impregnation of decomposed sulphides staining the gangue.

Bagazo. Waste from hand-jigging Mud from drill-hole.

Baja de metales (PERU). Lowering of ores from mine to mill.

Bajo. Foot-wall. (See also *Respaldo.*)

Balanza. Small scales.

Balanzón. Mainbeam or balance-bob of a Cornish pumping-engine.

Balsa. Movable platform suspended from cable. Pool of stagnant water in a mine.

Banco. Crucible of blast-furnace. A "horse." A "cross-course."

Banco de herrar. Horseshoeing shop.

Banda. Belt.

Bandeada. Banded structure of veins.

Bandera. A flag used in surveying to mark points.

Bartolina. Mine entrance.

Baño. Excess of mercury added to the *torta* to collect amalgam.

Barba. Fire-bridge.

Barilla. Vegetable alkali. Alkaline ashes. Grains of native copper found in certain ores. Native copper concentrates.

Bario. Barium.

Barómetro. Barometer.

Barquin. Bellows.

Barra. Bar or ingot. A share in a mine. (The ancient Spanish laws considered a mine as divided into 24 parts, each of which was called a *barra*. **Barras viudas** or **aviadas** are non-assessable shares, which participate in the profits, but not in the expenses of mining.) —— **azuela.** Bar with chisel-bit. —— **de plata.** Silver in bars. —— **pica,** or —— **de punta.** Bar with diamond-shaped point. —— **de uña.** Claw-bar for spikes.

Barranca. A ravine or gulch.

Barrena. A hand-drill for blasting. —— **viva.** A sharp drill. —— **muerta.** A dull drill.

Barrenar. To drill. To fire a round of holes.

Barrenarse. To connect with each other (as two mines or workings).

Barreno. A drill-hole. A communication between two workings. —— **de agua.** A downward hole. —— **en seco.** An upward hole.

Barreta. Crowbar.

Barreta perdida (PERU). Dead-work in unprofitable prospecting.

Barretero. A first-class miner, able to locate, direct, drill and knows how to blast holes, and to work with gad, etc.

Barril. Barrel.

Barro. Clay.

Bartolina. Watchman's house at mine-entrance.

Báscula. Scale for weighing charges.

Bastimento. Miner's luncheon.

Basura de plomo. Lead-dross.

Batea. A wide and shallow vessel, usually of wood, used for panning ore.

Batería. Battery.

Batiboléo. Company of miners working a stope of high-grade ore.

Bazofia (PERU). Waste rock.

Beneficiar. To treat ores for extraction of metallic contents; to beneficiate.

Beneficio. Metallurgical process.

Berilio. Berillium.

Berilo. Beryl.

Betún. Bitumen.

Bicharra (PERU). Small furnace with inclined stack.

Bigornia. (See *Yunque.*) Anvil.

Bimbalete (PERU). Crude ore-mill operated by two men. The grinder is a large stone with transverse bar by which a rocking motion is given. (See also *Quimbalete.*)

Bismuto. Bismuth.

Bituminoso. Bituminous.

Blenda. Zincblende.

Boca. Mouth of mine or tunnel, especially the place generally used as an entrance. Head of a stull or post. Heavy horizontal brace.

Boca de barrena. The bit of a drill

Bocarte. Stamp-battery.

Bochorno. Excessive heat, with lack of ventilation. (See *Vapores.*)

Bodoque. Argentite.

Boina. Miner's cap.

Bola de grasa. Slag-ball.

Bolèo. Dump for waste rock. Float-mineral. A kidney of ore.

Boliche. Dolly-tub (PERU). Small ore-mill like a *Quimbalete.*

Bollo (PERU). Pocket of ore. Triangular block of amalgam.

Bolsa. Pocket; small bunch of ore.

Bolsón. Pocket of ore. Large circular valley.

Bolsonadas (PERU). Pockety veins.

Bomba. Pump.

Bombillo. Cartridge (as of dynamite).

Bonanza. Literally, "fine weather." In mining, rich ground.

Bonete. Hat used to catch very rich ore as it is picked down with a sharp bar.

Bonito. First class silver-ore, *i.e.*, assaying over 1000 oz. per ton.

Bordo. Pillar left to support vein-matter. Block of ground ready for stoping.

Bornita. Bornite.

Boro. Boron.

Borra. Vein-matter. Lead-dross. Barren vein-matter or rock. —— **de veta.** Soft rotten rock. —— **en borra.** Same as *en borrasca.*

Borrasca. The opposite of *Bonanza.* When the mine has a vein, but no ore, it is said to be "*en borrasca.*"

Bosque. Forest, grove.

Bota. Bucket made of entire ox-skins, to take out water.

Bote. Boat, can, ore-bucket.

Bóveda. Flue leading to stack. Arch.

Bóvedas (MEX.), or **Bovedones** (PERU). Large vaulted stopes or caves.

Boya (PERU). Rich vein or pocket of ore.

Braguetilla (PERU). Smelting-furnace; the simplest being merely a hole in the ground.

Brecha. Breccia.

Brillo. Luster.

Broca. Drill-bit.

Bromo. Bromine.

Bronce. Iron or copper pyrites. Bronze. —— **fosforado.** Phosphor-bronze.

Bronco. Wild, loose. Roof-rock, liable to fall.

Bronquear. To hammer or pry with hammer or gad in rock which is loose and liable to fall.

Brossa (BATOPILAS). Rich ore containing two-thirds silver.

Brotazon de veta. Apex of vein; croppings.

Broza (PERU). Very poor ores which generally do not repay extraction.

Brújula. Magnetic compass.

Bufa. Cliff.

Buitrón (SP.). A silver-furnace of peculiar form. (MEX.) Fire-box. (PERU) Sump of masonry for settling pulp after grinding and before taking to patio.

Bujía. Candle, candle-power.

Buque. Boy employed in a mine.

Burbuja. Blister.

Burrero. Donkey-boy.

Burro. A windlass. A donkey. A carpenter's horse.

Busca. A quantity of ore extracted by a *campero* or *buscon.*

Buscónes. Miners working in abandoned mines either to get and sell ore, or to obtain a reward for some valuable discovery. Prospectors. (See *Camperos.*)

Cabeceado. End-line of claim (old).

Caballeriza. Stable.

Caballete. Ridge-beam, trestle, etc. —— **de tension.** Tension-station of cable-tram.

Caballo. Miners' candlestick. "Horse." Cross-course. Rope sling for lowering men in shaft.

Cabecera. "Heads" in concentration.

Cabeza. Head or end. —— **de ingenio** (PERU). Shaft of a vertical water-wheel.

Cabezada. End-piece in shaft-timbering.

Cabezal. Cap in timbering.

Cabezuela. Rich concentrates, usually containing both gold and silver. Mineral crushed to less than ¼ in. in diameter.

Cable. Cable or hoisting-rope. —— **de porte.** Carrying rope. —— **de traccion, de motor, de móvil.** Traction-rope; traveling-rope.

Cable-via aëreo. Aërial cable tramway.

Cabrestante. Capstan, winch.

Cabo. Handle. Stump of candle. Sub-foreman or "boss."

Cachetear. To loosen a gad by striking it alternately on each side.

Cachí (PERU). A "Quechua" word, meaning salt; also applied to all kinds of white gangue-rocks.

Cachucha. Miner's cap.

Cadena. Chain. A unit of linear measurement.

Cadmio. Cadmium.

Caducar. To forfeit a title through non-compliance with the stipulations contained therein.

Caducidad. The act of forfeiting at title, etc. (as above).

Caer de Cruz. The beginning of the action of the quicksilver in the process of amalgamation.

Caido. A fall of ground.

Caiman. Ore-shoot. Stilson wrench.

Caja. Case; box. Water-jacket of furnace. Housing of crusher. —— **chica.** Furnace-tap jacket. —— **fundida,** —— **quemada.** Burnt-out furnace-jacket.

Cajas (PERU). Vein-walls.

Cajete. A masonry basin to receive the pulp from an arrastre.

Cajón (PERU). Box; caisson. Load of about 3 tons (variable in different localities). Shoot. Drain. —— **del tiro.** Shaft-compartment.

Cajonero. The man who receives, registers and distributes the mine-cars at the shaft-mouth.

Cal. Lime.

Cala (SP.). Prospecting-pit.

Calabrote. A rope of large diameter.

Calamaco. Large piece of rock, difficult to break up.

Calavera. (See *Calamaco.*)

Calcar. To make a tracingof a drawing.

Calcareo. Calcareous.

Calcedonia. Calcedony.

Calcin. Roasting-furnace.

Calcinar. To calcine or roast.

Calcio. Calcium.

Calco. A tracing on cloth or paper.

Caldear. To glow with heat.

Caldera. Steam-boiler.

Calderista, or **Calderero.** Boiler-maker.

Calecero. Man who rides on hoisting-cage and gives the signals.

Calentadura. The first bar of lead treated by a lead-refining furnace.

Calentar los cuerpos (PERU). The turning yellow of mercury in patio-amalgamation.

Calera. Lime-kiln, calcining furnace.

Calero. Lime-burner. Roaster-man.

Calesa. Buckets for ore or water.

Calicanto (MEX.). Masonry work (PERU). Auriferous conglomerate in Chuquibamba, Peru.

Calichal. Second-class silver-ore (carrying from 150 to 1000 oz. per ton).

Caliche. Feldspar. Travertine; almost any lime carbonate not crystalline or stratified (PERU). Whitish clay in the selvage of veins (CHILI). Crude nitrate rock.

Caliente. Hot. The condition when mercury flours in amalgamation.

Caliza. Limestone.
Calza. Shim; liner.
Calzar. To sheathe or face with metal. To shim; to tamp.
Callapos (PERU). Rude wooden steps at the mouth of a mine.
Cambiar. To switch.
Cambia-vía. Turn-table; man who operates switch.
Cambio. Switch.
Camino. Road; gallery or shaft in a mine, used for general traffic.
Camino de rieles. Track.
Camon. Iron tire of mill-wheel.
Campana. Bell. (See *Capellina.*)
Campanela. Upper drill-hole.
Campanero. Bell-man, or station-tender.
Campero. The foreman in charge of *Campos.* Miners working on tribute.
Campo. A limited lease of a small section of ground in a mine. Mining camp. (See *Real.*)
Canal. Channel. Spout. —— **de humo.** Flue.
Canasta. Basket.
Canastillo. Tramway-bucket.
Cancha (SP.). Place for drying slimes or sorting ore. Mine dump.
Canchero (PERU). Person in charge of dumping and sorting of ores.
Candelero. Candlestick. Part of drill-hole remaining after blasting (PERU). Piece of clay on which retort-silver is laid for final heating
Candil. Oil-lamp.
Cantera. Building-stone. Quarry.
Canto. Narrowest face of a timber. **de canto.** Edgewise.
Cañada. (See *Barranca.*)
Cáñamo. Twine made of hemp.
Cañon. Gorge, precipitous ravine. Mine-level, drift or gallery. —— **de guía.** Drift along the vein.
Cañuela. Fuse.
Capa. Flat deposit of ore or capping of lava, clay, etc.; stratum.
Capacho (PERU). Leather bag for carrying ore.
Caparrosa. Vitriol; copperas.
Capela. Strap passing over a man's shoulders from handles of a wheelbarrow.
Capellina. Old-fashioned bell retort for silver amalgam.
Caperuza (PERU). Iron or earthen cylinder, placed over amalgam in distilling, so that the open lower end is in water, into which the condensing mercury drops.
Capitan, or **Capataz.** Mine-captain. —— **de patio.** Surface-boss.
Caponazo. Blow on the hand of man holding drill, due to fault of striker.
Capote. The bell-shaped iron cover fitting over the *capellina,* in retorting, to confine the heat.
Càpsula. Blasting-cap.
Cara. Facet of crystal.
Carbón, or **Carbón de leña, vejetal.** Charcoal. —— **de piedra.** Mineral coal.
Carbonato. Carbonate.
Carbonero. Coke- or coal-wheeler.
Carbonífero. Carboniferous.
Carbono. The element carbon.
Carburo. Carbide.
Cárcamo. Culvert. Pent stock of turbine.
Cárceles. Hitches or steps for timbers.
Cardenillo. Ruby-silver. Verdigris or carbonate of copper.
Carga. A charge, as for a furnace. A mule-load, generally of 300 lbs. Avoir., but variable in different places. —— **de arrastre.** Charge for an arrastre; usually about 200 lbs. Avoir.
Cargador. Feeder of a furnace. Ore carrier. Porter.
Cargar. To charge a furnace.
Cargo (PERU). The first portion of mercury added to an amalgamating-charge.
Carguero. Charger for a furnace.
Carne de vaca (PERU). Coarse-grained galena, generally mixed with gray copper-ore.

Carrana (Peru). Light rawhide shovel for throwing *taquia* into a furnace.
Carrascal. Honey-combed quartz, generally barren.
Carrera. Stroke—as of a piston.
Carrero. Charge-wheeler. Trammer.
Carretilla. Wheelbarrow.
Carrillo. Pulley-block.
Carrizo. Small hole in rock for wooden plug. (Also, see *Chocolon.*)
Carro. Charging-buggy. Mine car.
Cartucho. Explosive cartridge.
Casar metales (Peru). To mix ores for amalgamation or smelting.
Cascajo. Gravel. Waste rock. Oxidized free-milling ore.
Casiterita. Cassiterite.
Casquillos. Blasting-caps.
Castellano. A small furnace about 48 inches high, 10 inches square, used for lead-smelting, probably introduced by the Spaniards.
Castigar. To smooth or plane surfaces of rocks or boards.
Castillo. Gallows-frame.
Cata. Prospect-hole, or pit.
Catar, or **Catear.** To prospect.
Cateador. Prospector.
Cauce. River, water channel. Bed of a stream or river.
Cazadera. (See *Cárceles.*)
Cazar. To ram with a piece of timber.
Cazeador (Sp.). Amalgamator.
Cazo. A vessel for hot amalgamation. Any large copper or iron vessel.
Cebar. To melt rich ores, or lead bullion, etc., in a smelting furnace. To add small quantities of material, from time to time, to the bath in a furnace. Generally, to feed any kind of metallurgical machinery or process.
Cedazo. Screen or sieve. (See *Criba.*)
Ceja. In vanning with horn spoon or miners' pan, the heaviest streak or concentrate that appears at the edge.
Celasa. Cage.
Cemento or **Cimento.** Cement.
Cendrada. The cupel-hearth of a furnace in which silver is refined or rich lead cupelled. Made of finely-pulverized clay or other absorbent earth, mixed with ashes of bone or wood.
Cendradilla. A small reverberatory in which rich silver ores are crudely smelted. Also called *Galeme.*
Cenicera. Ashpit.
Cenizas. (Literally, ashes.) Gray silver-mineral. —— **de huesos.** Bone ash.
Centro. Center.
Ceñido. Narrowed.
Cepillo. Brush. —— **chico.** Shaper. —— **grande.** Planer.
Cepo. A notch in which timber is fixed.
Cerargirita. (See *Plata cornea.*) Cerargyrite.
Cerio. Cerium.
Cernidor. Moving screen; trommel.
Cerro. Hill.
Cerusita. Cerussite.
Cesio. Cæsium.
Chacuaco. Cupel furnace with absorbent hearth.
Chacurruscar (Peru). To mix several kinds of ore.
Chaflan. Inclined winze; bevel.
Chalchihuitl. Any green precious stone.
Chalcopirita. Chalcopyrite.
Chalcosina. Sulphide of copper.
Chamuscar (Peru). A superficial roasting or calcination, to facilitate the grinding of ore.
Chancar (Peru). Cobbing of ores.
Chapa. Metal plate, a lock. Foliated structure.
Chaqueta. Furnace-jacket.
Chaquiris (Peru). Ore-carriers in mines.
Charco. A pool of water.
Charqueador. The striker in two-handed drilling. The helper who, under the old system, sorted the

material from ground worked down by the miner. (See *Achicador.*)

Charquear. To dip out water from pools within a mine, throwing it into gutters or pipes which will conduct it to the shaft. (See *Achicar.*)

Chifladero. Ore-hopper.

Chiflarse. To waste itself (as the force of an explosion, through a fissure in the rock).

Chiflón. A narrow drift directed obliquely downwards. Any pipe from which issues water or air under pressure, or at high velocity. A strong draft of air.

Chile (PERU). Greatest depth of a mine.

Chileno. A Chilian mill.

Chiluca. A variety of porphyry.

Chimenéa. Chimney, smokestack; vertical shaft.

Chingarse. (PERU.) To be cut off, or to "peter out" (of a vein).

Chiquihuite. Ore-basket.

Chispa. Spark. Ore containing visible gold. A nugget.

Chispeada (BATOPILAS). Rich silver-ore with one-third silver.

Chispiador (PERU). Gold-washer in river placers.

Chiva. A bar with claw for drawing spikes.

Chiviar. To hunt for broken ore in waste.

Choclo de oro (PERU). A mass of native gold (say 1 oz. or more) in its matrix.

Chocolon. The part of the hole remaining in the rock after a blast. Hitch in the rock.

Chocú (PERU). Disease caused by inhaling fine mineral dust in stamp-mill.

Cholla. Opening or hollow space. A small space filled with soft ore.

Chorreadero. Chute for ore. Loose or running ground.

Chorrera. Ore-shoot; a run of loose rock.

Chorro. Spring of water found in mines. Jet or spout of liquid.

Chuga. (See *Puruña.*)

Chulana. An upper drill-hole.

Chumacera. Bearing for the shaft of a machine.

Chumbe. Zincblende.

Chumpe (PERU). (See *Chumbe.*)

Chuza. Catch-basin for mercury.

Cianógeno. Cyanogen.

Cianuro. Cyanide.

Cielo. Roof; ceiling. **Trabajar de cielo.** Overhead stoping.

Cigüairo, or **Civairo** (PERU). Peacock-colored.

Cigueña. Windlass. Crank.

Cilíndrico. Cylindrical.

Cilindros. Rolls.

Cima. Summit.

Cimborrio. (See *Cielo.*)

Cimbra. Center for arch.

Cinabrio. Cinnabar.

Cincel (PERU). Native silver in large masses. Chisel.

Cincho. Hoop.

Cinta. Streak or ore. Lacing. **—— para medir.** Measuring-tape.

Circo, or **Buitron** (PERU). Amalgamating circle.

Cítrico. Citric.

Civa. Stump of candle.

Civairo (PERU). (See *Cigüairo.*)

Claco. An old coin equal to $\frac{1}{8}$ of a Mexican *real.* (See *Tlaco.*)

Clapete. Clack valve.

Clavar. To nail; to drive a stake.

Clavo. Nail. **—— bueno,** or **rico.** Rich pocket of ore. **—— de metal.** Ore-shoot; pay-streak.

Clivage (PERU). Cleavage.

Cloro. Chlorine.

Clorurar. To chloridize.

Coagular. To coagulate.

Cobaltita. Cobaltite.

Cobalto. Cobalt.

Cobre. Copper. **—— abigarrado.** Bornite. **—— amarillo.** Copper pyrites. **—— azul.** Azurite.

Cobre gris. Gray copper; tetrahedrite. —— **negro.** Black or blister-copper. —— **roseta.** Rose-copper; ingot-copper. —— **roso.** Red oxide of copper. —— **verde.** Malachite. —— **virgen.** Native copper.

Cobrizo. Ore containing copper.

Cocer metal. To roast ore.

Cocha, or **Noque** (PERU). Crude settling-tanks built of stones for pulp, between mill and patio; Lake.

Coche, or **Cochina.** Rock-crusher. A large anvil.

Cochizo (PERU). Gray copper-ore.

Cocimiento (PERU). Obsolete method of extraction by boiling the ores.

Codo. Elbow.

Cohete. Rocket; fuse; torpedo; blast.

Cok. Coke.

Cola. Tail. Glue.

Coladera. Rather coarse screen.

Colada. Cast (metal).

Colas. Tailings.

Colero. Boss in charge of *peónes.*

Colgantes. Hangers.

Colina. Hill.

Colindantes. Neighboring mining properties, not more than 100 meters apart.

Color. Gangue stained with mineral, but not valuable.

Colorados. Red or oxidized ores (generally colored by iron oxide). The region of a mineral vein which includes the oxidized portion. Gossan.

Colote. A special basket used for handling earth, etc., by *cargadores;* is slung on the back, and usually provided with a short tail-rope for quick dumping.

Colpa (PERU). Iron sulphate.

Colpas (CHILE). Lump-ore.

Columna. Standard for cable-tramway. Column. Vertical damper.

Comalillo. Damper in a furnace-flue.

Comba (PERU). Sledge for breaking ore.

Comer. To eat. —— **alevante.** To break or stope ore. **Comerse los pilares.** To take out the last vestiges of mineral from sides and pillars of a mine.

Compacto. Compact.

Componer con madera. To timber a mine.

Compuerta. Sluice-gate.

Cóncavo. Concave.

Concentrador. Concentrator.

Concentrados. Concentrates.

Concentrar metal. To concentrate ore.

Concoide. Conchoidal.

Concreción. Concretion.

Conducta. A bullion train. The bullion carried.

Conglomerado. Conglomerate.

Consumido. The mercury consumed and lost in an amalgamation-process.

Contacto. Contact.

Contador. Accounting officer.

Contra. The person who carries away the material dumped at the mouth of a shaft. —— **cañon.** Drift in country-rock, parallel with drift on vein. —— **cielo.** Top of a drift; a raise. —— **mina.** Countermine. A communication between mines, or a tunnel communicating with a shaft. —— **pozo.** Upraise. —— **seña.** Bell-signal.

Contraguía. Movable guide-pulley over shaft.

Contrata. The instrument by which the parties assure the contract.

Contratista. Contractor.

Contrato. Pact or agreement between parties to perform some act; a contract.

Convexo. Convex.

Copador. Blacksmith's fuller.

Copalillo. Zincblende.

Copela. Cupel.

Copelar. To cupel.

Copelilla. Lead carbonate.

Copella. (See *Pella.*)

Cordillera. Mountain range.
Coribronce. Chalcopyrite.
Corindón, or **Corundo.** Corundum.
Cormano. Loading-chute.
Cornamusa (PERU). Earthen retort with movable cover.
Cornea (PERU). Horn-silver.
Coro-coro (BOLIVIA). Grains of native copper mixed with pyrite, chalcopyrite, etc. (PERU). Crude native copper concentrates.
Corpa (PERU). An ore containing galena, gray copper and native silver. Sulphate of iron.
Corral. Stableyard or enclosure.
Correa. Leather strap.
Corrido. The strike of a vein.
Corriente. Current (PERU). All the operations required for extracting metal on a large scale from one class of ore.
Cortafr´o. Cold chisel.
Cortar pilar. To form a rock support or pillar in a mine.
Cortar sogas. Literally, to cut the ropes. To abandon a mine, taking everything useful or movable.
Corte (PERU). Opening to an ore-deposit, either a shaft or drift. Pay-streak left clear so that ore can be knocked down without becoming mixed with waste.
Corte de caja. Balance sheet of accounts.
Corteza. Crust.
Costal. Sack or bag.
Costalera. Ore-sacks (collectively).
Costeable. Sufficiently rich to pay expenses at least (said of ore, ground, stopes, etc.).
Costearse. To pay for itself.
Costo de los jornales. The labor working-cost.
Cotenze. Miner's sashcloth, or breech-clout. Coarse hempen cloth similar to burlaps. (See *Patío.*)
Covacha. A cave or crevice.
Coyote. A man who buys and sells mining shares.
Coz. Hitch for stull.
Craza. Vessel to receive molten metal.
Creston. Outcrop or apex of a vein.
Creta. Chalk.
Cretacio. Cretaceous.
Criadero. A mineral deposit of irregular form, not vein-like. A chamber in a vein, filled with ore. Any mineral deposit. This is the more modern sense, and the word is so used in the Mining Laws at present in force in Mexico.
Criba. Screen or sieve. —— **giratoria.** Revolving screen or trommel. (See *Cedazo.*) Hand-jig. (See *Harnero.*)
Cribadores. Ore-screeners.
Crisocola. Chrysocolla.
Crisol. Crucible. Melting-pot. Slag-pot
Crisolero. Slag-pot puller.
Cristalino. Crystalline.
Cromo. Chromium.
Croquis. Sketch.
Crucero. Cross-cut.
Cruz. Cross. Intersection of two ways. Arms of a scale.
Caudrilla. Gang of laborers; working company.
Cuadro. Square set. Set of shaft-timbers. (See *Marco.*)
Cuajado. Dull lead-ore.
Cuarcita. Quartzite.
Cuartea. Work on drill-holes, paid for by the foot, yard, meter, etc.
Cuarto. A shift. —— **primero.** Day-shift. —— **segundo.** Afternoon-shift. —— **tercero.** Night-shift.
Cuartón. Large boulder.
Cuarzo. Quartz. —— **porfídico** (PERU). Hornstone.
Cuaternario. Quaternary.
Cubeta. Bucket.
Cúbico. Cubic.
Cubo. Bucket; the third power of a number.
Cuchara. Spoon. Ladle. Utensil made of horn, in which minerals are washed as a rough test of value (PERU). Blade of water wheel.

Cucharilla. Iron rod. used in drilling, to keep a dry hole clean.
Cucurucho. Leather cover to protect miners at work from falling water or rocks.
Cuele. Distance run in tunnel or other work during a certain time.
Cuello. Flange.
Cuenca. Broad valley. Geological basin.
Cuerda. Cord. Limits of a mining property.
Cuero. Hide. Leather bucket.
Cuerpo. Ore-body (PERU). Mass of pulp in process of amalgamation.
Cuesco. Coarse ore; a re-cemented, fragmentary rock.
Cuesta. Declivity. Slope.
Cueva. Cave.
Cumbre. Top, summit.
Cuña. Wedge; gad.
Cuprita. Cuprite.
Curador. Guardian of property. Trustee.
Curva. Curve.

Dado. Die.
Dar cuele. To drive a level.
Dejar respaldado (PERU). To leave valuable ore in the wall-rock.
Demasía. Unoccupied ground between two mining concessions, less than one *pertenencia* in extent.
Densidad. Density.
Denuncio. Denouncement; the act of applying for a mining concession under the old mining laws.
Dependiente. Clerk.
Depósito. Ore-bin or large tank.
Derrocar. Overthrow.
Derrumbe, or **Derrumbamiento.** The caving-in of mine-workings. Landslide.
Desaguador (SP.). Water-pipe; drain.
Desaguar con bomba. (See *Sacar.*)
Desagüe. Unwatering; mine-drainage.
Desatornillador. Screwdriver.
Desbocarse el barreno (PERU). To remain (as a drill-hole) practically intact after firing.
Desbordar. To stope. To rob mine-pillars.
Desborde. Underhand stope.
Descargar. Literally, to unload. —— **un horno.** To tear down a furnace.
Descubridora. Discovery-mine; first mine in a district, or on a mineral deposit.
Desecho. The loss of mercury through chemical reactions during amalgamation; lead-dross; assay waste.
Desengranar. To throw out of gear.
Desierto. Desert.
Desistimiento. The abandonment of a mining claim.
Deslizarse el Azogue (PERU). The flouring of mercury.
Desmontar. To clear away barren rock or rubbish.
Desmontes. Poor ores.
Desmorro. Furnace-barrings.
Desnivel. Difference in a level.
Despacho. Office. Station. (See *Ventanilla.*)
Despajar. To remove waste rock by concentration.
Despaje. Concentration-tailings.
Despensa. Store-room. Locked room for rich ore.
Despilar, or **Despilarar.** To rob a mine.
Despoblado. Ore with much gangue.
Despoblar. To suspend mining work.
Destajero. A contractor for piece-work.
Destajo. A contract. Piece-work, as distinguished from time-work.
Diabasa. Diabase.
Diablo. Rail-bender. Kind of barrow used for moving heavy weights.
Diamante. Diamond.
Diámetro. Diameter.
Dibujo. Drawing; design.
Diente. Tooth. Binding-stone in Mexican masonry. (See *Tizon.*)
Diluir. To dilute.

Dimorfo. Dimorphous.
Dinámica. Dynamics.
Dinamita. Dynamite.
Dinamo. Dynamo.
Diorita. Diorite.
Dique. A mineral dike. Dam.
Dirección. Strike.
Disfrute. Exploitation. **Obras de disfrute.** Stopes. etc.
Dislocación. Fault in vein.
Dobla (PERU). Night-shift.
Doblar. To bend. To work two shifts in succession.
Dócil. Docile; malleable; free milling.
Dolerita. Dolerite.
Dolomia. Dolomite.
Doma. Dome.
Dragonera (PERU). Passage of the flame into the furnace at the fire-bridge.
Duela. Stave of a barrel or cask, etc. Stone of a floor, etc. Flooring board.
Dueño. Owner; shipper of ore.
Dureza. Hardness.
Durmiente. Railroad-sleeper; sill of a set of timbers.

Echadero. Level place near a mine, where ore is cleaned, piled, weighed and loaded. Also called *patio* of the mine.
Echado. Dip.
Echar planilla. Gobbing; packing; filling with waste material.
Efervescencia. Effervescence.
Eflorescencia (PERU). Outcrop.
Eje. Axle; axis.
Ejido. Grazing-place. Common.
Electricidad. Electricity.
Elevante. Overhand stope.
Elipse. Ellipse.
Embarcarse la veta (PERU). To be lost (as a vein) by reason of a fault or intersecting dike.
Embije. Thinly laminated mineral structure.
Émbolo. Piston.
Emborrascarse. To become barren by pinching out, etc.
Embozado. Rich mineral entirely imbedded and concealed in barren rock.
Embudo. Funnel; hopper.
Empalmar. To splice, to join.
Empalme. Splice in a rope. Timber joint; junction of roads.
Emparejar. To square up.
Enagenada. A change of ownership.
Encampanado. A shaft which does not reach the lower level of the mine.
Encapillar. To start work in a new gallery.
Encargado. Superintendent.
Encina. Oak. —— **blanca.** White oak. —— **negra.** Black oak.
Encoger. To shrink.
Enfriar. To add to the *torta* substances which reduce cupric to cuprous salts.
Enganchar. To couple.
Enganche, Aparato de. Grip.
Engranaje. Gearing.
Engranar. To throw into gear.
Engrane. Gear.
Engrasadura. Grease-cup.
Ensalmoro. Addition of salt to the *torta.*
Ensancharse. When a vein widens.
Ensayador. Assayer.
Ensayar. To assay.
Ensaye. Assay. Assay-office.
Ensayo real (PERU). Assay made by bringing low-grade bullion to the assay of coin silver or gold. Pre-assay.
Entibador. (See *Ademador.*)
Entibar. (See *Ademar.*)
Entresuelo. Gallery between two levels.
Envainado. Lost or left to one side (as a vein).
Escalera. Ladder; in Mexican mines generally made of notched sticks. —— **de barrotes.** Mine-ladder with rounds. —— **de muescas.** Mine-ladder of notched timber.

Escantillón. Wooden ruler used by timbermen. Pattern. Gauge.
Escarche (Peru). Native silver in thin plates.
Escombros. Waste-rock.
Escoria. Slag or cinders.
Escorial. Slag-pile.
Escorificador. Scorifier, in assaying.
Escuadra. Change of direction of 90°. Square.
Escurrir. To leak, to drip, to drain off.
Eslabón. Link.
Esmeralda. Emerald.
Esmeril. Emery.
Espato calizo. Calcspar.
Espátula. Spatula.
Espejado (Peru). Galena.
Espejuelo. Mineral with spicular character. Zincblende (Peru). Lead carbonate mixed with galena and gray copper.
Espeque. Handspike. Wooden lever. The long arm or lever in machinery moved by animal power.
Espesor. Thickness.
Espetón. The tapping-bar of a smelting furnace.
Espoleta. The blasting-charge for a small blast. Primer or blasting-fuse.
Esponja. Spongy bullion, after retorting and before melting.
Espuela. Additional quantity of copper sulphate required in the *torta*, when not enough was added at first.
Espuma. Scum.
Esquisto Schist.
Estacada. Palisade. Lagging.
Estaca. Lagging of round poles. Stake.
Estación. (See *Ventanilla.*)
Estadía. Leveling-rod.
Estado (Peru). A measure of length ($2\frac{2}{3}$ varas). Approximately a fathom.
Estalactitas. Stalactites.
Estalagmitas. Stalagmites.
Estampillas. Stamps with which the Government taxes are paid. Postage stamps.
Estanque. Tank; reservoir.
Estaño. Tin; cassiterite.
Este. (See *Oriente*) East.
Esteatita. Steatite.
Esteos. Vertical beams supporting the pulley of a hoist.
Estibnita. Stibnite.
Estopa. Cotton waste.
Estoraque. Resin. Yellow zinc-blende.
Estratificacion. Stratification.
Estratos. Strata.
Estrellarse la veta (Peru). To "peter out," or become lean, especially by scattering.
Estriada. Striated.
Estribo. Stirrup; hog-back in a mountain.
Estroncio. Strontium.
Estrujón. Second collection of amalgam, generally very pasty.
Éter. Ether.
Exagonal. Hexagonal.
Excavar. To excavate.
Excéntrico. Eccentric.
Exhibición. Exhibition; assessment.
Exploración. Exploration. Prospect.
Explosivo. Explosive.
Explotar. To exploit.
Expropiar. To expropriate.
Extraer. To extract.
Extraviado. Astray in a mine.

Faenas. Tasks. ——**muertas.** Dead-work.
Faiscador. Placer-miner; gold-washer.
Faja. Longitudinal banded or ribbon-structure.
Falda. Slope; flank of hill.
Falla. Vein of soft rock at right-angles to drift. Fault.
Falso. Treacherous (ground). (See *Flojo.*)

Famulia (PERU). Wedge; gad.
Fanega. Variable unit of dry measure, usually 90.815 liters; of superficial measure usually 3.5663 hectares.
Fango, Colector de. Mud-drum.
Farallón (PERU). Outcrop projecting above country-rock.
Feldespato. Feldspar.
Felsita. Felsite.
Ferricianuro. Ferricyanide.
Ferrocarril. Railroad.
Ferrocianuro. Ferrocyanide.
Ferroso. Ferruginous.
Fibra. Filament.
Fibrosa. Fibrous.
Fierro. Metallic iron. Matte. Speiss. (See *Hierro.*) —— **blanco.** Arsenical pyrite. —— **viejo** (PERU). Silver-ores consisting mainly of iron oxide. —— **espejado.** Specular iron-ore.
Fierros. Low-grade silver-ores (from 20 to 35 oz. per ton). "Abzug" and "Abstrich" from refining lead.
Filón. Small stringer; intersecting vein.
Filtrar. To filter. To sink in.
Finos. Fine ore; "fines."
Fisura. Fissure.
Flaqueza (PERU). Leanness. Shaly structure. The overhanging section of a precipice.
Flecha. Machinery-shafting.
Flete. Freight-charges. Freight.
Flojedad. (See *Aflojadero.*)
Flojo. Weak; loose. **Terreno ——.** Loose ground.
Fluorescencia. Fluorescence.
Foco. Electric arc or incandescent lamp.
Fogaña de horno (PERU). Fire-pit of a furnace.
Fogata. Fumes from blasting.
Fogón. Hearth. Firebox.
Fogonero. Boiler-fireman.
Fondeo. Temporary staging in a shaft.
Fondo. Bottom.
Fondón. A large *cazo* with copper shoes and bottom.
Fonolito. Phonolite.
Formación. Formation.
Formal. Regular; undisturbed.
Formalizar. To formalize a contract or other legal paper.
Forros. Lagging.
Fosforescencia. Phosphorescence.
Fósforo. Phosphorus.
Fósil. Fossil.
Fosilífera. Fossiliferous.
Fractura. Fracture.
Fragua. Forge; blacksmith's shop.
Freno. Bridle; brake. (See *Garrote.*)
Frente. Breast of working or face of drift. —— **de guía.** Main or guiding level in a mine.
Fresno. Ash tree.
Frijolillo (GUANAJUATO). Round fragments of limestone with calcareous cement.
Frío. Cold. In amalgamation, the condition of "sickened" mercury.
Frontón. Face of a drift, etc. Any working-face.
Frutos. Ores.
Fuelle. Bellows. (See *Barquin.*)
Fulminantes. Blasting-caps.
Fundición. Smelting-plant.
Fundidor. Smelter.
Fundir. To smelt.
Fundo minero. All the *pertenencias* embraced under one title.
Fuque. Deepest point of excavation.
Furgon. Box or closed freight car.

Gabarro. Ore in large pieces, from egg-size up.
Galápago. Turtle-shaped pig of lead. English saddle.
Galemador. A silver-furnace (PERU). A small furnace for roasting silver-ores.
Galemar. To reduce ore in a Mexican furnace.
Galeme. Reverberatory furnace. (See *Cendradilla.*)
Galera. Shed; long or narrow room; storehouse.

Galería. A gallery.
Galio. Gallium.
Gallos. Rich specimens, particularly those that show native gold or silver.
Gambucino. Prospector.
Gancho. Hook of any kind. Dog used for extracting tapping-bars from furnace.
Ganga (PERU). Gangue.
Garabato. Curved iron bar used in copper-smelting.
Garrapata. Clamp for stretching wires.
Garrote. Brake. (See *Freno.*)
Garrotero. Railway brakeman.
Gaseoso. Gaseous.
Gasto. Expense; cost.
Gato. Jackscrew. Railbender.
Gaz. Gas.
Geoda. Geode.
Geografía. Geography.
Geología. Geology.
Gerente. Business manager.
Gis. Chalk crayon pencil.
Globosa. Globular.
Golpeador. Striker, in hand-drilling.
Goma. India-rubber.
Gorra. Miner's hat of felt, stiffened with pitch.
Gorrón (PERU). Lower pivot of the vertical shaft in an ore-grinding mill.
Gotear. To drip gently; to leak.
Grado. Degree.
Graduador. Manometer, or blast-gauge.
Grafito. Graphite.
Granate. Garnet.
Granito. Granite.
Granular. Granular.
Granza. Metallic minerals, from the size of rice to that of hens' eggs.
Grasa. Slags from smelting operations. Grease.
Grasero. Slag-pile.
Grena. Undressed ore.
Greta. Litharge.
Grieta. Crevice; fissure.
Grifo. Valve-cock.
Grueso. Lump-ore.
Guairona (PERU). Guard-rails at mouth of a shaft.
Guaje. Gourd for water.
Gualdra. Long and stout beam, generally sustaining other beams, or a heavy weight.
Guarache (PERU). Work in over-time, generally at night; sandal.
Guardafierros. Tool-man.
Guarda raya. Landmark; monument. The end- and side-lines of a mining claim.
Guarda. Immediately adjacent country rock. Guard.
Guardatiro. Person issuing mining supplies to the miners.
Guía. Indications (of a vein or pay-streak, or of metal in a panning-test). Guide for cage in shaft.
Guija. Gangue. Sometimes applied to quartz; a pebble.
Guijarro. Pebble.
Guijo. Pointed pivot, upon which turns the upright centerpiece of an *arrastre*, a door, etc.
Guijoso. Quartzy.
Guíngaro. Pickaxe. (See *Huíngaro.*)

Habilitar (PERU). To furnish working-funds for a mine or mill.
Hacha. Axe.
Hachazuela. Adze.
Hachita. Hatchet.
Hacienda. Works; estate. —— **de beneficio.** Metallurgical works. —— **de Fundicion.** Smelting works. —— **de maquila.** Custom mill.
Hallazgo. Discovery.
Harina (PERU). Pulp.
Harnerero. Operator of a hand-jig.
Harnero. Hand-jig.
Hatajo. Drove of pack-mules.
Hebilla. Buckle.
Hematita. Hematite.
Hembra. Post (timbering).
Herramienta. Tools. Equipment.

In Guanajuato used instead of *Parada* (which see).

Herrero. Blacksmith.

Hervir. To boil.

Hichu (PERU). A species of long grass used as fuel or fodder.

Hidrato. Hydrate.

Hidráulica Hydraulics.

Hidrocianógeno. Hydrocyanogen.

Hidrógeno. Hydrogen.

Hidrografía. Hydrography.

Hierro. Iron. —— **arcillosa**, or **globoso.** Limonite. —— **arsenical.** Arsenical pyrites. —— **cromado.** Chromite. —— **dulce.** Weld-iron. —— **especular.** Spiegeleisen. —— **fundido.** Pig-iron. —— **magnético.** Magnetite.

Hijuela. Seam of ore; a small drain.

Hijuelas. A small-sized torta, made up as a sort of assay on a large scale. with from one to five kilogrammes of argentiferous mud.

Hilo. Thread; pay streak; small stringer of ore. (PERU). Strike of a vein.

Hogar. Hearth of a furnace.

Hoja. Leaf; sheet.

Hoja de lata. Tinned sheet-iron.

Hojalatero. Tinsmith.

Hollin. Fume; condensed furnace-smoke; soot.

Honda. Rope-chair for descending shaft. Sling.

Hormiguillar (PERU). To add salt and some water to the amalgamating charge.

Hornillo. Reverberatory furnace.

Horno. Furnace. **Alto horno.** Blast furnace.

Horquilla. Coke-fork.

Hoyo. Hole (in the ground).

Huacal. Crate. Bowl. Drinking-dipper made of a gourd.

Huachaca (PERU). The portion of ore belonging to the laborer who operates on shares.

Huaillaripa (PERU). Thief of gold-ore.

Huaillaripear (PERU). To steal gold-ore. To extract gold from tailings by means of sheepskins in a gentle current of water.

Huaira (PERU). Ancient Indian smelting furnace (still used in Potosi, Bolivia).

Huairacañon (PERU). Brattice, generally of wood.

Huairuna (PERU). Small earthen retort, used for retorting amalgam, extracting from 5 lbs. to 15 lbs. silver.

Hueco. Empty space. (See *Demasía* and *Pertenencia.*)

Hueja. Bowl made from a gourd. (See *Jicara.*)

Huella. A trace of gold or silver in assaying.

Huíngaro. Pick. (See *Guíngaro.*)

Hule. India-rubber.

Hulla. Pit coal.

Humedad. Moisture.

Humildes metales (PERU). Silver-ores which amalgamate readily without sickening or flouring the mercury.

Humo. Fume; smoke.

Humpe (PERU). Carbonic acid in mines; choke-damp.

Hundido. (See *Derrumbe.*)

Igneo. Igneous.

Iman. Magnet. **Piedra iman,** lodestone.

Impermeable. Impermeable. Waterproof.

Impuesto minero. The tax paid on mining claims.

Inclinado. Inclined.

Incorporadero. Place where the *incorporo* is effected.

Incorporo. The adding and mixing of mercury and other ingredients for the *patio* process.

Indicador. Indicator. Gauge.

Indio. Indian.

Informe. Report.

Ingeniero. Engineer.

Ingenio. Engine (PERU). Crude ore-

mill, used in *patio* amalgamation (PERU). Crude amalgamating mill, having water wheel *below* the grindstones.

Intendencia. An official district.

Interventor. A trustee or receiver for a mine in dispute. Inspector.

Invasión. A mining trespass.

Iodo. Iodine.

Iridio. Iridium.

Jaboncillo. Decomposed talcose rock, or hardened clay, generally found in a vein, and sometimes indicating the proximity of rich ore.

Jacal. Miner's cabin; storehouse for mine supplies; shaft house.

Jales, Jalsontles. Rich tailings or middlings from concentration or amalgamation.

Jalon. Tall survey-stake. Ranging pole.

Jarcia. Fabric or cordage of *Ixtle* fiber.

Jaspe. Jasper.

Jaula. Cage.

Jícara. A vanning-bowl; bowl made from tree-gourd. (See *Hueja.*)

Jito. Gate in casting.

Jornada, or **Jornal.** Day's work.

Juego. A set of anything, as, a set of repair parts for a machine.

Juquero (PERU). Thief who takes ore from the vein.

Jurásico. Jurassic.

Labor. Mine-workings in general. Specifically, a stope, or any other place where ore is being taken out.

Laboreo. Working on the vein.

Lacolita. Laccolite.

Ladero. Declivity; side track.

Ladrillo. Brick. **—— de fuego.** Firebrick.

Ladron. Robber.

Lama. Literally, slime. The argentiferous mud which is treated by any amalgamation process; sometimes applied to tailings. Mud in vein.

Lamero. Place of deposit for *lamas.* (See *Cajete.*)

Lámina de fierro. Sheet-iron.

Lampazo. A sort of broom formed of green branches on the end of a long stick, to dampen the flame in a reverberatory furnace.

Lancera. An inclined stull.

Laques (PERU). Deposits of water in a vein. Druses.

Larguero. Cap or side-piece in shaft-timber.

Latitud. Latitude.

Latón. Brass. **—— blanco.** German silver.

Lavadero. Literally, a washing place. A tank with stirring arrangement, to loosen up the argentiferous mud from the patio, and dilute the same with water, so that the silver amalgam may have a chance to precipitate. An agitator (PERU). Placer deposit.

Lavador. A rod, used in drilling, to keep a wet hole clean. The rod is made by striking the end of a long fibrous stick against a harder substance until it is flat and soft.

Lazado. A running noose.

Lazadores. Men formerly employed in recruiting Indians for work in the mines, by the process of lassoing them!

Lazo. A light cord of fiber.

Lecho. A bed.

Lechoso. Milky. A variety of opal.

Legua. League; equal to 2.604 English miles or 4.19 kilometers. One square league is called *sitio de ganado mayor*, and is equal to 4338.1123 acres.

Lente. Lens.

Leña. Fuel-wood.

Leñador, or **Leñero.** Cutter, carrier or supplier of fuel-wood.

Levantamiento. Elevation.

Levantar planos. To survey.

Levante. Breast of a stope; **al levante,** overhand stoping.
Ley. Literally, law. In mining, the proportion of precious and other metals in any mineral compound. Grade of ore.
Licuación. Liquation.
Liga. Alloy. Lead flux for smelting dry ores. Galena, rich in silver.
Lignito. Lignite
Lima. File.
Limadura. Literally, filings. The mercurial globules seen when a piece of argentiferous mud from a patio is assayed by washing in a spoon or saucer.
Limpiador. Ore-sorter.
Limpio. Clean.
Lindero. Boundary.
Lingote. Ingot.
Linternilla. Driver of a horse-whim.
Lipta (PERU). Ash-colored or gray silver-ores, accompanying tin-lodes.
Líquido. Liquid.
Lis. The flouring of mercury.
Litio. Lithium.
Litología. Lithology.
Litro. Liter.
Lixiviar. To lixiviate.
Lodo. Mud.
Logaritmo. Logarithm.
Loma. A low hill.
Lomerío. A series of lomas.
Lona. Canvass.
Longitud. Longitude.
Losa. Flagstone.
Losero. A quarry for *losa* stone.
Loza. Pottery.
Lubricante. Lubricant.
Lumbrera. Ventilating shaft; port-hole in furnace.
Luz de arco. Arc-light. (See *Foco.*)

Llama. Flame.
Llamar. To signal for the cage or bucket.
Llampo (PERU). Ore found in condition of powder, generally very rich.
Llancar (PERU). To extract ores from very narrow veins, by means of rods, 7 to 10 ft. long.
Llano. A plain.
Llanta. Wheel-tire.
Llanura. Extensive plain.
Llapar (PERU). To add quicksilver to the pulp when the amount already added is in the condition of amalgam.
Llave. Any piece of mine timber. Strut or key. Wrench. **—— Inglesa,** or **—— de tuerca.** Monkey wrench.
Llicteria (PERU). A Bolivian ore containing lead, tin, zinc and silver.
Llimpi (PERU). Ores of red color, generally cinnabar.

Machacado (PERU). Native silver in ore.
Machacar. To crush.
Machete. A large knife heavy enough for chopping.
Machihembrar. To dovetail, or join with tenon or tongue and groove.
Machote. A stake, or permanent bench mark, fixed in an underground working, from which the length and progress thereof is measured.
Machucador. Crusher.
Macizo. Unworked lode. Solid; abutment.
Madera. Lumber.
Maestro (PERU). The principal trough in *patio* amalgamation, in which all the amalgam is gathered. **—— Mecanico**. Master-mechanic.
Magistral. Roasted copper pyrites, used when sulphate of copper is not obtainable for amalgamating purposes.
Magnético. Magnetic.
Magnetismo. Magnetism.
Magnetita. Magnetite.
Malacate. Windlass. Horse-whim. Any mining hoist. **—— de araña.** Capstan.

Malaquita. Malachite.
Malla. Mesh of a screen.
Mamposteria. Mason-work.
Manantial. A spring of water.
Mandón. Overseer or boss.
Manero. Single-hand miners'hammer
Manga. Conical canvas bag to drain quicksilver out of amalgam. Hose. Tuyere-sack.
Manganeso. Manganese.
Mango. Handle for pick or hammer.
Manguera. Hose.
Manguito. Sleeve.
Mano. The grinding-stone of an arrastre, etc. —— **de fierro.** Bucking-board muller.
Manta. Blanket-vein.
Mantas. Sacks of jute or heniquen, etc., for carrying ore, etc.
Mantear. To hoist.
Mantéo. Hoisting. An inclined hoist.
Mantero. Man who loads material to be hoisted in a shaft.
Manto. Pocket.
Maquila. Smelting- or treatment-charge. —— **y flete.** Freight and treatment-charge.
Maquilar. To work ore for its owner on shares, or for money.
Maquilero (Peru). Ore-buyer.
Máquina. Machine. —— **exploradora.** Diamond-drill machine.
Marcasita. Marcasite.
Marco. Set of shaft-timbers; square set. Timber frame of any kind. A weight of 8 oz. avoir.
Marga. Marl.
Marmajas. Concentrated sulphides.
Mármol. Marble.
Marqueta. Bar of lead bullion (Peru). Retort-silver.
Marro. Sledge-hammer.
Martillo. Single-hand hammer.
Masa (Peru). Pulp. —— **derecha** (Peru). Vertical ore-deposit. —— **echada,** horizontal ore-deposit.
Mata. Matte.
Matriz. Matrix.
Mazo. Striking-hammer. Stamp for crushing ore.
Mecapal. Sheet-iron scraper used by ore-sorters. Flat strap or rope that goes over the head of a porter to support the load.
Mecate. Coarse twine. Twine made of Maguey fibre or Ixtle. (See *Lazo.*)
Mecha. Fuse. Wick for a lamp or a candle. Torch.
Media barreta (Peru). Inclined shaft.
Medir. To measure. To survey.
Memoria. Pay-roll.
Mena. Mineral vein. **Menas.** Ores.
Merced. Gift, grant, or concession.
Mercurio. Mercury. —— **corneo.** Calomel.
Meridiana. Meridian.
Merma. Ore lost by abrasion during treatment or transportation.
Mesa. Concentration table. Hearth of furnace. Plateau.
Metal. Any metalliferous mineral. —— **azul.** Lead ore. —— **crudo** (Peru). Oxidized ore. —— **de ayuda.** Fluxing-ore of any kind. —— **de cebo.** Very rich ore, usually treated in small reverberatory furnaces. —— **de correr.** Very pure tin ore. —— **de fuego.** Smelting-ores. —— **de pie.** Ore amenable to the patio process. —— **de quema** (Peru). Sulphide ore. —— **en piedra** (Peru). Crude ore. —— **jugeso.** Wet ore, *i.e.*, lead-ore. —— **negro.** (See *Blenda.*) —— **ordinario.** Common ore. —— **pepena.** The best class of selected ore.
Metalada. Discovery of ore in barren working.
Metalurgia. Metallurgy.
Metamórfico. Metamorphic.
Metamorfosis. Metamorphism.
Metapil. The grinding-stone of an arrastre, etc. (See *Mano.*)
Metate. Iron bucking-board for grinding ore-samples.
Mezcla. Furnace-charge. Mortar.

Millon. An ore-pile.
Mina. Mine.
Mineral. Mining district.
Minería. Mining, embracing the whole subject.
Minero. A mine owner; a mining captain; an underground boss. —— **de cuarto.** Shift boss. —— **mayor.** Head mining-captain.
Mineta (PERU). Small mine chamber or cavity.
Mixta. Alloy of gold and silver.
Mogrollo. (See *Metal de cebo.*)
Mojón, or **Mojonera.** Stone pillar to mark corner of a claim. Any boundary-mark.
Molde. Mould.
Moledora (PERU). Upper millstone.
Moler. To grind. —— **en seco** (PERU.) Dry grinding. —— **por sutil** (PERU). Wet grinding.
Molíbdeno. Molybdenum.
Molienda. Charge of ore to be ground and amalgamated.
Molino. Ore-grinding mill. —— **de balas.** Ball mill. —— **chileno.** Chili mill. —— **de muestras.** Sample-grinder.
Molonque. Rich specimen, of which one-half, or more, is silver.
Mono. Vertical stull.
Montaña. Country-rock.
Montón. Pile (of ore or other material). Old unit of weight for ores, equivalent in some districts to 3000, and in others to 3200, Mex. lbs., of 0.4602 kg.
Mordaza. A mortise.
Morillos. Round poles for light timbering.
Morro. Furnace wall-accretions.
Mortero. Mortar.
Mosqueado. Rock mineralized in specks.
Mostrador. Sampler.
Motor. A motor.
Mozo. Boy. Man of all work. Roustabout.
Muelle. Elastic spring. (See *Resorte.*)
Muesca. Notch in a stick; mortise; notch cut in a round or square beam for the purpose of using it as a ladder.
Muestra. Sample.
Mufla. Muffle. A rude cupel furnace for treating rich ore on a bath of lead. (See *Vaso.*)
Mula. Mule.
Multa. Penalty or fine.
Muro (PERU). Foot-wall.

Nata. (Same as *Escoria* or *Grasa.*)
Nativo. Native.
Negocio. Business; enterprise.
Negrillos. Negros. Black silver-ore; black sulphide of silver.
Niobio. Niobium.
Níquel. Nickel. —— **rojo.** Niccolite.
Nítrico. Nitric.
Nitrógeno. Nitrogen.
Nivel. Level. —— **del mar.** Sea-level.
Nódulos. Nodules.
Noque. (See *Cocha.*)
Noria. Endless chain of buckets.
Norte. North.
Nudo. Knot or button on traction-rope of tramway. Coupling.

Oblicuo. Inclined.
Obradora (buena ó mala). Rock that breaks well or badly.
Obras de disfrute. Workings from which ore is being extracted.
Obras muertas. Literally, "dead work." Work done in the country-rock.
Ocote. Pitch-pine.
Ocre. Ocher.
Octaedro. Octahedron.
Oeste. West. (See *Poniente.*)
Oficina. Office.
Ojo de Víbora. Yellow blend.
Ojos. Small, rich bunches of ore.
Ojosa. Honeycombed structure.
Oligista. Specular hematite.
Olla. Clay water-jar. Slag-pot.
Ollero. Slag-pot puller.
Ópalo. Opal.

Operario. A working miner
Ordinarios. Low-grade ores.
Oriente. East.
Oro. Gold.
Oroche. Low grade or yellowish silver. Bullion containing gold and silver. Doré.
Orrillaje. Sheet-lagging.
Ortoclasa. Orthoclase.
Osmio. Osmium.
Oxálico. Oxalic.
Óxido. Oxide.
Oxígeno. Oxygen.
Oyamel. Jack pine; spruce pine.

Pábilo. Wick.
Pacos. Ferruginous silver-ores (PERU). Oxidized ores.
Paja quemada (PERU). Jamesonite.
Pala. Shovel. —— **de chuso.** Round-pointed shovel. —— **cuadrada.** Square-pointed shovel.
Paladio. Palladium.
Palanca. Lever. Toggle of rock-crusher.
Palanque. Barring after shots have been fired.
Palero. Shoveler. Mine-carpenter, or timberman.
Palo. Stick. Piece of timber.
Palos labrados. Hewn timber. —— **redondos.** Round timber.
Panes. Amalgamating-pans.
Panino. Vein-formation. Vein-material. —— **muy macizo.** The very hardest kind of vein-matter or rock. —— **macizo.** Rock not quite so hard, but still not requiring to be timbered. —— **favorable.** Rock easily broken down by drilling, but not needing timbering. —— **blando.** Generally slate or schist with veins or spars which can broken out easily by pick, bar, or wedge, and which must, sooner or later, be timbered up. —— **muy blando.** Usually clay shale or argillaceous schist, and requiring constantly to be held up by timbering.
Paradas de busca. Miners working on tribute. —— **á la carga.** Miners working for so much per ton or "carga" of ore broken down or extracted. —— **á destajo.** Miners on contract, at so much per meter, etc. —— **á partido.** Miners receiving as pay a share of the ore they mine. —— **de hacienda,** or —— **de obra.** Miners working by the day.
Paralelo. Parallel.
Parcionero. Partner in a mining contract.
Pardo. Oxidized or surface ore. (See *Colorado.*)
Pared. Vein-wall.
Parihuela. Hand-barrow.
Parrilla. Grate-bar.
Partido. Division of ores between partners. Working a mine by *partido* is when the miners agree with the owners to take a certain part of the ores in place of wages. Usually the mine-owner provides candles, powder and steel, and keeps the drills sharpened, and receives, in payment of royalty and supplies, two-thirds or more of the ore taken out. This contract is renewed weekly or monthly, etc., and the proportion of ore retained by the miners is greater or smaller according to the richness of the stopes where they work. It is generally bought from them by the mine-owner himself, for various reasons.
Pasilla. Dry silver amalgam.
Pasta. Amalgam of gold or silver. Gold and silver bullion.
Pastura. Fodder for animals.
Patilla. Platform left in shaft.
Patío. Cloth used by miners.
Patio. Any paved enclosure, more or less surrounded by buildings. An ore-sorting yard. A floor or yard where argentiferous mud is treated by amalgamation.
Pechera. Leather or cloth, worn by

laborer packing ore, to protect neck and back.

Pedernal. Flint.

Pegador. Foreman in charge of blasting.

Pegar. To fire the loaded drill-holes.

Pella. Silver amalgam. **Plata Pella.** The same.

Pendiente. Gradient. Hanger. Grade.

Peña. Wall-rock.

Peón. Helper; laborer. —— **suelto.** Roustabout.

Pepenado (SP.). Dressed ore.

Pepenador. Ore-sorter.

Pepenar. To sort ore.

Pepita. Nugget.

Pérdida. Loss in *patio* amalgamation Loss in general. (See *Consumida.*)

Perfil. Profile.

Perforadora. Machine-drill.

Perito. An expert in any science or art.

Perla. Assay-bead.

Pertenencia. Mining claim. Under the modern Mexican Mining Law, a square of land 100 meters on a side (*i.e.*, 1 hectare = 2. 471 acres) is the minimum unit. This unit is called a *pertenencia.*

Pesador. Weighmaster.

Pesalicor. Water blast-gauge. Hydrometer.

Peso. Weight. Silver dollar. —— **bruto.** Gross weight. —— **neto.** Net weight.

Petanque, or **Petlanque.** Ruby silver. Tetrahedrite, and other rich silver minerals.

Petróleo. Petroleum.

Peya de Cobre. Copper amalgam.

Pez mineral. Mineral pitch. (See *Betun.*)

Picacho. Peak.

Picador. One who taps a furnace.

Picar. To tap a furnace for slag or bullion.

Pico. Pick-axe; miners' striking-hammer.

Pie. Brace. —— **de amigo.** Buttress or strut. —— **de gallo.** Diagonal brace. —— **derecho.** Vertical brace. Post.

Piedra bruta. Country-rock; barren rock.

Piedra córnea. Chert; flint.

Piedra de mano. Hand-specimen.

Pila. Stone tank.

Pilar. A pillar of rock or ore.

Pileta. Sump of a mine. Basin, pot or crucible of a smelting-furnace.

Pilón. Pestle of a mortar.

Pinta. Indication (by color, weight, structure, etc.) of the metallic value of an ore. —— **de metal.** Indications of ore ; spots of ore.

Piña. Cone for sample-grinder. In metallurgy, the same as *Pella.*

Piñon. Nut-pine. Pinîon.

Piqueta. Tap-hole. —— **de graza.** Slag-tap. —— **Plomo.** Lead-tap.

Piquete. Surveyor's stake on surface; small prospect-work of any kind.

Piramidal. Pyramidal.

Pirargirita. Pyrargyrite.

Pirita. Pyrites. (See *Bronce.*) —— **magnética.** Pyrrhotite.

Pirolusita. Pyrolusite.

Pirómetro. Pyrometer.

Piso. A level.

Pisón. Rammer.

Pistola. Small drill-hole.

Pizarra. Slate rock.

Pizarreña. Slaty structure.

Placas. Jaw-plates for crusher. —— **de unión.** Fish-plate.

Placeres. Secondary gravel deposits. Placers.

Plan. The lowest working in a mine. **Trabajar de plan.** To mine for depth ; to sink.

Plancha. Pig, ingot, bar, plate, thick sheet, or mass of any metal. Bucking-board. Mudsill. Steel sheet. Turn-plate. Amalgamating plate. A charge of roasted ore—about 70 lbs.

Planchera. Ingot-mould of sand, earth, or iron.

Planchuelas. Fish-plates.

Planilla. Inclined floor upon which

tailings are washed; stationary buddle. Sorting-table. Wooden skimmer for molten metal.

Planillero. A workman on the *planilla*, always paid according to amount of concentrates produced.

Plano. Floor of a mine-working. —— **inclinado.** Incline.

Plata. Silver —— **blanca.** Native silver. —— **ceniza.** Chloride of silver ore. —— **córnea amarilla.** Iodyrite. —— **córnea blanca.** Cerargyrite. —— **esponja.** Silver sponge. —— **maciza** (PERU). Native silver, generally in small sheets. —— **mixta.** Gold and silver alloy. —— **negra.** Argentite. —— **piña.** Silver bullion obtained by retorting amalgam, and not yet melted. —— **pasta.** Silver-bullion. Spongy silver bars after retorting. —— **verde.** Bromyrite; Embolite.

Platero. Silversmith.

Platillo. Scale pan. (See *Puruña.*)

Platino. Platinum.

Pliegue. Fold.

Plomada. Plumb-line, or plumb-bob.

Plomero. Lead-tapper. Furnace-man. Plumber.

Plomillos. Shots of lead found in slags.

Plomo. Lead. Lead-ore. —— **ronco** (PERU). Silver sulphide. —— **de obra.** Base lead-bullion ("work-lead").

Poblador. Shift-boss. The miner who points the holes.

Poblar. To set men at work in a mine.

Polea. Pulley; sheave.

Polvillos. Rich concentrates.

Polvo. Dust. Flue-dust.

Pólvora. Powder. Gunpowder.

Polvorero. Powder-monkey.

Polvorillas (PERU). Decomposed sulphide of silver.

Polvorín. Powder magazine.

Pomez. Pumice.

Poner en marcha (un horno). Blow in a furnace.

Poniente. West. (See *Oeste.*)

Pórfido, or **Pórfiro.** Porphyry.

Por pie. The *patio* process.

Porronguito (PERU). A crude quicksilver measure.

Poste. Post.

Potasio. Potassium.

Pozo. Winze or shaft. —— **al cielo.** Vertical winze upward. —— **de arrastre.** Inclined winze downward. —— **y patilla.** Passage, with alternating vertical and inclined portions, for the transportation of ore and waste to the surface on the backs of laborers.

Precipitador. Workman in a leaching-mill who adds the precipitant to the silver solutions.

Prensa. Vise. Press.

Presa. Reservoir.

Propiedad minera. Mining claim.

Prórroga. An extension of time.

Prueba. A test. —— **de crudo.** A test made when the *torta* is supposed to be *rendida*, or worked, to ascertain whether there is sufficient mercury present.

Pudinga. Pudding stone; conglomerate.

Pueble. The actual working of a mine. The total working-force employed in a mine. A shift.

Puente. Bridge. Suspended platform in stope or shaft. Stull.

Puerta. Gate. —— **de graza.** Slag-tap. —— **de plomo.** Lead-tap.

Puertas. Massive barren rocks, or "horses," occurring in a vein, which must be removed to regain the pay streak.

Puerto. Port; a mountain pass.

Pulgada. Inch.

Punta Small cord for tying ore-sacks.

Puntal. Prop.

Puntista. The laborer who knocks down all loose rock in the face or stope, leaving it ready for the next shift.

Puño. Handful.

Purgar. To blow off a boiler.
Puruña (Peru). Small earthen vanning plaque about 7 to 8 inches diameter for making amalgamating tests or controlling the operations of the *patio*.

Quebrador. Rock-crusher; an ore-sorter.
Quebrazon de veta. Break in vein.
Quema. A roast of ore; the process of roasting ore; retorting amalgam.
Quemadero. A burning-place; a retorting-furnace for silver or gold amalgam.
Quemado. Literally, burnt stuff. Any dark, cindery-looking mineral encountered in a vein or mineral deposit (generally manganiferous).
Quemazones. Silver-ores containing black peroxide of manganese (Peru). Outcrop.
Quiebra. Break or fault.
Quijadas. Rock-breaker; jaw-plates.
Quilate. Carat.
Quimbalete (Peru). (See *Bimbalete*).
Químico. Chemist or assayer.
Quintal. An ancient weight equal to 4 *arrobas*, or 46.0246 kilograms.
Quitapepena. A watchman who searches the miners as they come out of the mine.
Quinto. Mining tribute from American colonies to the King of Spain.

Rajas. Lagging (half-round).
Ramal. Branch-vein.
Ramalear. To branch off into various divisions.
Raspar. To clean up an arrastre.
Rastrillo. Rake. Stirrer for moving ore in a furnace. A rabble.
Rastron. A Chilian mill.
Rata. Candle-boy.
Raya. Day's pay.
Rayador. Time-keeper.
Rayar. To pay off.
Rayarse. To register after work in the mine.
Real. A mining camp; royal; a Spanish coin. —— **hacienda.** Royal treasury. —— **de minas.** A town having silver-mines in its vicinity.
Reata. Light rope.
Rebaje. The blasting down of a hill-side. In general, any excavation other than the driving of a face or sinking of a shaft. Underhand stoping. Surface excavation.
Rebosadero. Gossan.
Rebosador (Peru). River gold-placers.
Recibir con madera. (See *Componer.*)
Recoger. To collect.
Reconcentrados. Concentrates.
Recuesto. Dip.
Red. Network.
Rédito. Interest.
Refaccion, pieza de. Repair-piece.
Refaccionero. The helper of a rock-drill operative.
Refogar. To retort amalgam.
Refraccion. Refraction.
Regular. Fair or average.
Reja. Grating.
Relámpago (Relampaguear). The brightening of the silver button during cupellation.
Relaves. Residue left in a *batea* from a washing-test.
Reliz. Wall of vein. —— **del alto.** Hanging-wall. —— **del bajo.** Foot-wall.
Relleno. Back-filling.
Remache. Rivet.
Remisión. Shipment.
Rendimiento de metal. Ore-output.
Rendir. To yield. The total amalgamation of the silver in a *patio* charge.
Repasador. Man who turns over pulp in the *patio*.
Repaso (Repasar). The act of mixing the *patio* charge by treading it with horses or mules.
Reposadero. The bottom of a crucible or pot in an upright smelting-furnace.

Reposadores. Settling-tanks.
Rescatador. Ore-buyer.
Rescate. Purchase of ores. Purchased ores.
Resecos. "Dry" ores.
Resorte. Spring. Spring-buffer (of rolls).
Respaldo. Wall of a vein. —— **alto.** Hanging-wall. —— **bajo.** Foot-wall.
Retaque. Filling.
Retenida. Pillar in a stope.
Retorta. Retort.
Reverberar. To roast.
Revoltura. Mixture; furnace-charge.
Rezaga. Waste rock.
Rezagado. Piled up.
Rico. Rich.
Riel. Rail.
Riñon. Kidney of ore.
Río. River.
Risco. Sharp, precipitous rock. Quartz found in veins or outcrops.
Roble. Oak. (See *Encina.*)
Roca. Rock.
Rodillo. Roller.
Roldana. Sheave.
Rollo de porta cable. Bearing-drum of cable-tramway.
Romana. Steelyard. —— **de bascula.** Platform-scale. —— **de gancho.** Steelyard. —— **de plancha.** Charging-scale.
Romaneador. Weigher.
Rondana. Gasket; washer.
Rosca. Screw-thread.
Rosicler. Ruby silver.
Rubí. Ruby.
Rueda. Wheel.
Rumbo. Direction; strike of a vein.

Saca. A bag full of ore. A mine is said to be *de buena saca* when it has large, accessible ore-reserves.
Sacabocado. Punch.
Sacabón, Sacavón. (See *Socavón.*)
Sacar. To draw or bale out. —— **con bomba.** To pump.
Sal. Salt.
Salbanda. Slickensides.
Salina. Salt deposit; salt-pit.
Salitre. Saltpeter.
Salmuera. Brine.
Salón. Chamber.
Saltierra. Earthy, impure salt.
Sangrar. To tap (a furnaec).
Sangría. Cross-cut from shaft to vein.
Sapo (Rana). Railway-frog.
Sardina. A cross-cut saw.
Sarten. Pan for drying moisture samples. Frying-pan.
Secador. Sample-drier.
Sección. Section.
Sedimentario. Sedimentary.
Selenio. Selenium.
Seno. Sine.
Serrucho Hand-saw.
Siderita. Siderite.
Sienita. Syenite.
Sierra. A mountain range; a saw.
Sifon. Downtake of blast-furnace. Syphon.
Sílice. Silica.
Sobarba. Tappet.
Sobrestante. Foreman.
Socavón. Mining-tunnel. Adit. —— **á hilo de veta.** Drift. —— **crucero.** Cross-cut.
Sodio. Sodium.
Soga. Rope or thick cord; cable for hoisting.
Solayo. Cutting-in hole.
Solera. Rest for grate-bars, etc. (PERU). Lower millstone.
Solicitud. The application for a mining claim. Petition.
Sólido. Solid.
Sondear. To sink a prospect bore-hole.
Sondeo. Prospect bore-hole.
Soplador. Blower.
Soplar. To furnish blast for a furnace.
Soplete. Blowpipe. Tuyere. **Ensaye al soplete.** Blowpipe assay.
Soplo. Blast.
Soquete. Clay for stopping furnace-tap. Clay in vein.
Soquetero. One who wets and kneads clay to be used at the furnace.

Soroche plomoso. Lead carbonate. —— **reluciente.** Argentiferous galena.
Soyote. Vug.
Sueldo. Salary; wages.
Suelo. Bottom; surface of ground.
Sulfato. Copper sulphate.
Sulfuros. Sulphide-ores; rich sulphides of silver from lixiviation processes.
Superficie. Surface.
Sur. South.

Tabique. A partition-wall in a mine.
Tabla. Board or plank. The broader face of beam or timber; one of the sides or front of an excavation. —— **de alto.** Hanging-wall. —— **de bajo.** Foot-wall.
Tabladillo (PERU). Crude amalgamating mill having water-wheel *above* grindstones.
Tablero. Tally-board.
Tablón. Wooden plank.
Tahona. *Arrastre* moved by water-power.
Tahonero. The man in charge of the *tahona.*
Tajo abierto. Open-cut work.
Talache. Mattock.
Taladrar. To bore or drill.
Taladro. Drill. —— **de punta de diamante.** Diamond drill.
Talco. Talc.
Talega. Coin bag.
Talio. Thallium.
Teja. Tile.
Tambor. Hoisting-drum.
Tamiz. Fine screen.
Tanate. Leather, hide, or jute bag to carry ore or waste rock.
Tanatero. A laborer, or bag-carrier.
Tanda. The ore or waste (usually waste) that is knocked down or loosened in driving a face or sinking a shaft.
Tangente. Tangent.
Tanque. Tank.
Tapa. Cover.
Tapar. To stop a furnace-tap with clay.
Tapextle. A working platform or stage built up in a stope, or anywhere in a mine. A landing-place between two flights of ladders.
Tapón. A plug.
Taponera. Dolly-bar.
Táquia (PERU). Llama-dung, used for fuel in roasting and smelting.
Tara. Tare weight.
Tarango. Platform in stope or shaft.
Tarea. Task; job. It is common in Mexico to engage common laborers by the *tarea.*
Tartárico. Tartaric.
Taza. Crucible of blast-furnace.
Techo. Roof; hanging-wall.
Tejo. Gold or silver ingot.
Tela de alambre. Fine wire-cloth.
Telégrafo. Telegraph.
Teluro. Tellurium.
Temesquitale. The earthy part of pulverized ore.
Temesquitate. A rich scoria or litharge from the process of cupellation.
Templar. To temper steel.
Tenazas. Tongs.
Tenedor de libros. Bookkeeper.
Tentadura. A sort of assay, made in a horn spoon, in an earthen saucer, or in a wide and shallow vessel of any kind, for the purpose of ascertaining the amount of amalgam present in a sample of argentiferous mud from an amalgamating patio. Any assay made by washing or "panning."
Teodolito. Theodolite; a surveying-transit.
Tepetate. Barren rock; attle; deads.
Teposteles. Polybasite.
Tepostetes (SONORA). Boulders of specular iron-ore found in gold-placers.
Tequezquite. Native carbonate and chloride of sodium.
Tequío. A task set as one day's work.

Ore broken from a given place or belonging to a given contractor. In some places, ore not rich enough to sack underground.

Tercería, or **Tercero en discordia.** Umpire.

Terciario. Tertiary.

Tercio. A sack of ore, about 150 pounds weight. A load for a *tanatero.* One-half load for a mule

Termómetro. Thermometer.

Terraja. Screw-cutter.

Terrapln. Embankment.

Terreno. Ground; formation; terrane. —— **movedizo.** (See *Panino muy blando.*)

Terrero. Mine-dump.

Terrosa. Earthy.

Testeras. Uprights in a mine, whether pillars, arches or posts.

Textura. Texture.

Tierra. Fine-sized ore.

Tierras (Sp.). Earth impregnated with mercury-ore. —— **de labor.** Dirt from a stope, mixed with particles of ore; fines. —— **de yunque.** Chips made in breaking and sorting ore.

Timbre. Bell. Stamp-tax.

Timbrero. Bell-man.

Tina. Mine-bucket. Tub. Leaching vat.

Tinaja. Basin of water in rock.

Tintero (Peru). Sump of shaft.

Tirantes. Small-sized hewn timber. Ties.

Tiro. Mine-shaft. A shot. —— **de arrastre**, or **de recueste.** Inclined shaft. —— **general.** Shaft used for various purposes at the same time; hence, a shaft of two or more compartments.

Titanio. Titanium.

Título. Title.

Tizon. Bond in masonry. (See *Diente.*)

Tlaco. An old coin. See (*Claco*).

Toba. Volcanic tufa. —— **caliza.** Calcareous tufa.

Tobera. Tuyere. (See also *Alcribis.*)

Toldo. Awning.

Tolva. Hopper. Ore-chute.

Tonel. Chlorinating- or amalgamating-barrel.

Tonelada. Ton.

Topacio. Topaz.

Tornillo. Bolt or screw.

Torno. A windlass; a turning-lathe.

Torta. Pie or cake. The heaps of argentiferous mud which are treated in the *patio.*

Tosca. Clayey vein-matter. Talc seam. (Catorce.) Soft, decomposed porphyry.

Tostar. To roast.

Tostador. A roasting-furnace.

Tramo. Block of ground, *i.e.*, linear space along tunnel or shaft, etc.

Tranca. Square set of timbers.

Tranvía. Tramway.

Trapiche. A primitive form of grinding-mill.

Traquítico. Trachytic.

Traquito. Trachyte.

Travertino. Travertine.

Trecho. A portion of space, distance or time.

Trementina. Turpentine.

Trilla. (See *Torta.*)

Trincha. Piled waste. Coke-fork.

Trinchera. A roughly stacked pile of rock or ore.

Trinquete. Pawl.

Trituradora. Rock-breaker. (See *Quebrador.*)

Triturar. To crush.

Trompa. "Nose" of chilled slag over a tuyere.

Trompo. Foot of a stull or post.

Tronco. Team of horses or mules.

Tronera. Chimney; channel; flue.

Trueque. Truck or trolley (for tramway-bucket). Truck of railway car.

Truncado. Truncated.

Tubo. Tube, pipe.

Tuerca. Screw-nut.

Tumbar. To break down ore, etc.

Tumbe. The act of breaking and removing ore.

Turbina. Turbine.
Turno. A shift of work.
Turquesa. Turquoise.

Unifaz. Single phase.
Unión. Coupling of wire-rope or of pipe.
Urano, or **Uranio.** Uranium.

Vacía. Empty.
Vaciador. One who dumps slag-pots.
Vaguada. Water-way. Stream-channel. Water-shed or divide.
Válvula. Valve.
Valle. Valley.
Vanadio. Vanadium.
Vapor. Steam. Bad air in mines.
Vara A measure; in Mexico, equal to 33 inches or 0.838 meters.
Varejon. Pole-lagging.
Vaso. Reverberatory for smelting rich ore, or for cupelling silver. Crucible of blast-furnace.
Vela. Candle.
Velador. Watchman.
Velocidad. Velocity.
Vena. Veinlet, not over 3 in. thick; a "knife-blade" vein.
Venero. A spring of water in a mine.
Venta. Sale.
Ventanilla. Station.
Ventanillero. An underground station tender.
Ventilación. Ventilation.
Ventilador. Fan; blower.
Vereda. Foot-path; trail.
Verídico. Trustworthy; veracious.
Vértice. Vertex.
Vertiente. Watershed.
Vestigio. A trace of gold or silver in assaying. (See *Huella.*)
Veta. Strictly, a fissure-vein; loosely, any mineral deposit. —— **clavada.** Vertical vein. —— **corrida.** Continuous vein. —— **crucera.** Cross-vein. —— **echada.** Inclined vein. —— **en borra.** Vein carrying no ore. —— **en frutos.** Vein carrying pay-ore. —— **ramal.** Branch-vein. —— **recostada.** Inclined vein. —— **serpenteada.** Vein of variable strike. —— **socia.** Companion or connecting vein. —— **transversal.** Cross-vein.
Vetillas. Slides. The grooves in a slickensides.
Vidrio. Glass.
Viga. Joist. (See *Tirantes.*)
Voladora (Peru). Upper millstone. One of the grinding-stones or mullers of an *arrastre.*
Volante. Fly-wheel.
Volcán. Volcano.
Volta. An electrical volt.
Vuelta. In refining silver, the moment when impurities have been removed.

Xacal. (See *Jacal.*)

Yacimiento. Ore-deposit.
Yelmo. Coke-fork.
Yeso. Gypsum.
Yunque. Anvil.

Zacate. Fodder for animals. Hay, cornstalks, etc.
Zafiro. Sapphire,
Zanja. Ditch.
Zapa-pico. Mattock. Pick.
Zapata. Brake-shoe.
Zaranda. Large ore-screen; grizzly.
Zarandero. One who attends the screen.
Zirconio. Zirconium.
Zona. Zone.
Zorra. Drill-boy or messenger.
Zurdo. Left-handed.
Zurrón. A rawhide ore-sack holding about 150 lbs.; a load for a *Tanatero.* (See *Tanate.*)

Bibliography of Mexican Geology and Mining.

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SECRETARY'S NOTE.—This valuable bibliography has been compiled :

1. By selecting from the larger list prepared by the distinguished author, and published in 1898 by the Department of *Fomento*, those items which concerned more or less directly economic geology and mining—the titles of many treatises on paleontology, vulcanism, meteorites, chemistry, etc., being omitted.

2. By adding to the catalogue thus formed the titles of later publications, kindly furnished by the author, and bringing the bibliography down to 1902.

The original numbers used by the author in the official publication of 1898 have been retained. Gaps in the series indicate titles omitted, as above explained, in this republication. Numbers followed by letters designate the titles of later date furnished by the author for interpolation.

The result, as here published, is arranged under three headings: I. Abbreviations Used in the Bibliography; II. Publications Arranged Alphabetically under Authors' Names; and III. Alphabetical Index of the Principal Localities Mentioned in the Bibliography.

I. ABBREVIATIONS USED IN THE BIBLIOGRAPHY.

Abhand. der K. Akad. der Wissenschaften.—Abhandlungen der Kaiserliche Akademie der Wissenschaten. Berlin.

Am. Geol.—The American Geologist. Minneapolis, Minn.

Am. J. Sc.—American Journal of Science. New Haven, Conn.

Am. Nat.—The American Naturalist. Philadelphia.

An. Acad. Mex. C.—Anuario de la Academia Mexicana de Ciencias Exactas, Físicas y Naturales, correspondiente de la Real de Madrid. México, 1896.

An. Col. Min.—Anuario del Colegio de Minería. México, 1845, 1848, 1859 y 1863.

Annals New York Ac. Sc.—Annals of the New York Academy of Sciences.

Ann. des Min.—Annales des Mines. Paris.

Ann. des Sc. Nat.—Annales des Sciences Naturelles. Paris.

Ann. K. K. Naturhistorischen Hofmuseum.—Annalen der K. K. Naturhistorischen Hofmuseum. Wien.

Ann. Rep. U. S. Geol. Survey.—Annual Report of the Director of the U. S. Geological Survey. Washington.

Ann. Scient. ed Ind.—Annuario Scientifico ed Industriale. Milano.

Ann. Soc. d'émulation des Vosges.—Annales de la Société d'émulation des Vosges.

Ans. Asoc. Ing. y Arq.—Anales de la Asociación de Ingenieros y Arquitectos de México.

Ans. M. de C.—Anales Mexicanos de Ciencias, etc. México, 1860.

Ans. M. F.—Anales del Ministerio de Fomento de la República Mexicana. Méx-

Arch. Comm. Sc. Mexique.—Archives de la Commission Scientifique du Mexique. Paris, 1865–1869.

Archiv. f. Min.—Archiv für Mineralogie.

Assoc. Fr. avanc. Sc.—Association Française pour l'avancement des Sciences.

Beitr. z. Geol. u. Pal. Mex.—Beiträge zur Geologie und Palaeontologie der Republik Mexico.

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Hertha.—(Publicaciôn citada por L. Agassiz en la *Bibliographia Zoologiæ et Geologiæ*).
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Proc. Soc. Nat. Hist.—Proceedings of the Society of Natural History. Boston.
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ERRATA.

So far as the Secretary is aware, the pages of this volume are free from error, with the sole exception of a single paper, of the text of which the following corrections were received from the author after the sheets had been printed:

PAGE	LINE	FROM	
399	14	bottom	"8 miles" should be "15 miles."
399	last		"50 to 75" should be "350 to 400."
400	16	top	Add, "The veins strike N–S, and dip from 45° to 75°."
400	10	bottom	"Alfreina" should be "Alfreña."
400	5	bottom	Substitute, "The larger veins can be traced 3 or 4 miles."
401	first		Substitute and add, so that the first sentence (beginning at the bottom of p. 400) will read: "The ores consist of lead and zinc sulphides and carbonates in quartz gangue. Rich gold- and silver-ores occur in the oxidized portions of the veins. Below water-level the gold-values are smaller, and the silver-values more constant."
401	12	top	"A 60-ton mill" should read, "a mill producing 50 tons of concentrates daily."
401	14	top	"Alfreina" should be "Alfreña"; and the mention of the *Palo Blanco* mine should be struck out.
401	15	top	"The product" should be "some of the product."
401	20	top	This line should be struck out, and the next should read, "The Montezuma," etc.
401	13	bottom	"250-ton" should be "200-ton."

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